Materials & Methods

VOLUME 27, NUMBER 2 • FEBRUARY, 1948

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hed Monthly by Reinhold Publishing ration, 330 West 42nd St., New York N. Y., U. S. A. Ralph Reinhold, Chair- f the Board; Philip H. Hubbard, Presi- H. Burton Lowe, Executive Vice Presi- and Treasurer; G. E. Cochran, Vice ent and Secretary; William P. Winsor, President; Francis M. Turner, Vice ent. Price 50 cents a copy. Payable in ce, one year, $4.00; two years, $5.00; years, $6.00 in U. S. and Possessions, a and Pan American Union. $2.00 for each year in all other countries. by New York Draft.)

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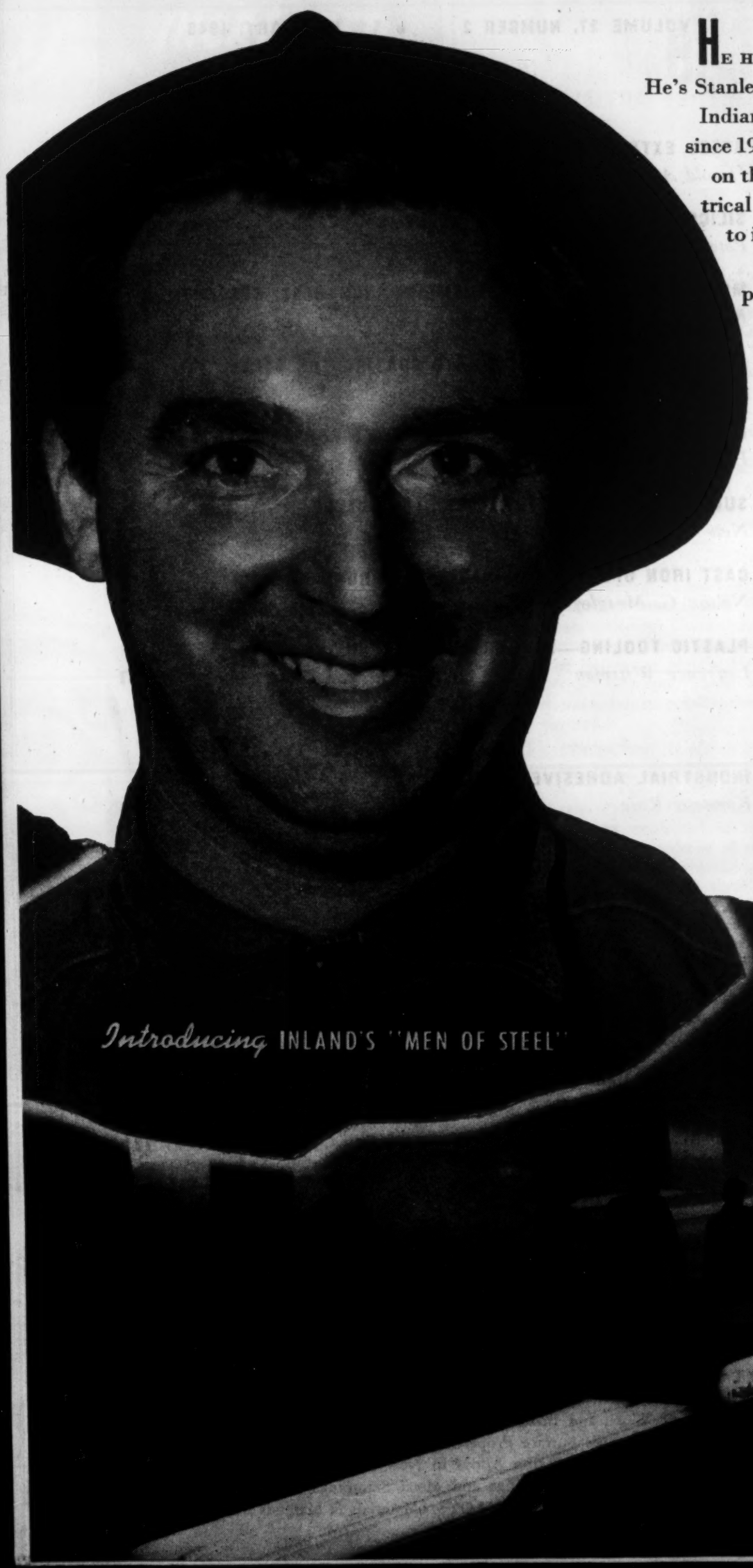
Re- d as second class matter Nov. 14, at the Post Office at New York, under the Act of March 3, 1879.

NEXT MONTH: Judicious Use of Available Steels Will Help Stretch Supplies . . . Proper Heat Treatment Prevents Cracking of Tool Steels . . . Welding Can Be Used to Repair Worn and Broken Zinc Die Castings . . . New Coating for Polystyrene Plastics Improves Surface Properties . . . Short-Run Forming of Steel With Soft-Metal Dies . . . Hard-Facing Alloys in New Forms Permit Use of Automatic Welders . . . Nonmetallic Moldings and Metal Stampings Combined in Electrical Products . . . CAST ALUMINUM ALLOYS (Materials & Methods Manual No. 35)

He Keeps the Wheels Turning...



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The MATERIALS OUTLOOK...

THE SITUATION IN STAINLESS STEEL—Some industry leaders feel that the government warnings on use of materials containing so-called scarce alloying elements are exaggerated. They cite stainless steel. Those who know the true situation say that twice as much stainless could be produced next year without any danger of exhausting the supplies of chromium available to us.

ELECTROLESS PLATING—Extensive commercial application of a new, promising "electroless" process for nickel and cobalt plating is said to be dependent upon a lowering in cost of sodium hypophosphite. The chemical is the principal ingredient of the chemical reduction plating bath used in the process. This method of plating is said by the Bureau of Standards—which developed it—to be ideal for plating parts with recesses and enclosed areas that are difficult to electroplate. Present price of sodium hypophosphite ranges from 60 to 70¢ per lb. If volume increases this price can be reduced one-third.

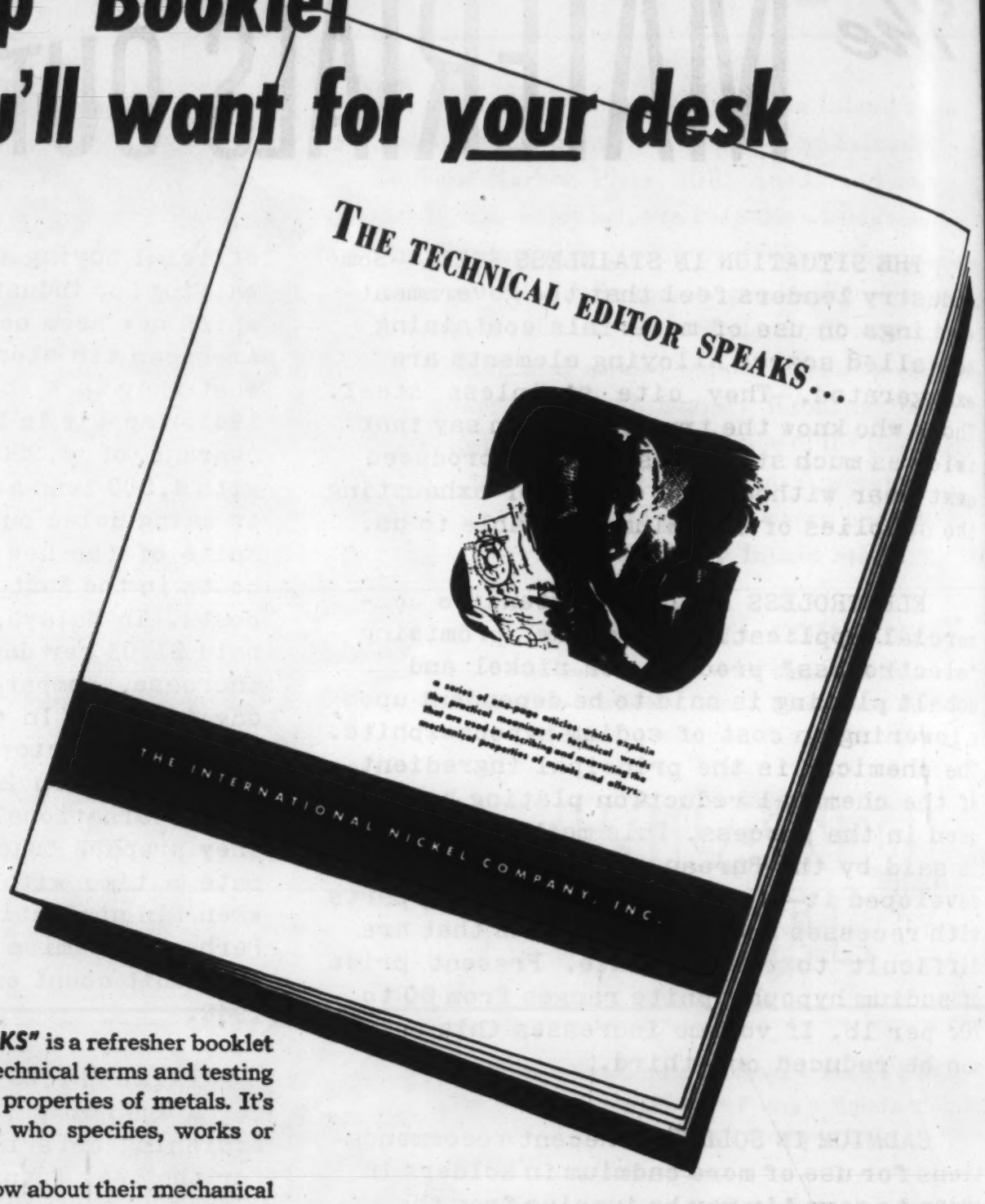
CADMIUM IN SOLDERS—Recent recommendations for use of more cadmium in solders in order to save tin may be jumping from the frying pan into the fire. The supply of cadmium is limited, and the present price is more than double the 1940 price. Even though cadmium solders have a restricted field of application, their use could not be extended greatly without creating a tighter situation in the cadmium supply. Cadmium still remains an excellent electro-plate finish for iron and steel parts where price and relative scarcity are not so important because of the small amounts needed for the plates.

TIN OUTLOOK STILL DARK—Washington officials are in an almost despairing mood about the future supply of tin. The amount wanted for the emergency stockpile would take all imports for two years. Plans for official buying are still held in abeyance waiting for industrial demands to be met, which now seem nowhere in sight. Total American tin stocks are now less than half what they were when we entered the war in 1941. Imports in 1947 dropped down to an average of 4,220 tons a month, compared with 4,500 tons a month in 1946. World tin is being doled out on a famine basis. In spite of the new giant dredges, dredging costs in the East Indies are double the 1939 costs. In Malaya, unskilled labor is now paid $1.03 per day plus 91¢ cost of living increase, compared with only 55¢ a day in 1939. In the face of all the unfavorable factors, the Tin Producers Association in London has recommended to the International Tin Study Group that they prepare "such a plan as will anticipate a time within the next few years when tin production will exceed demand." Perhaps optimism is an admirable virtue, but don't count on any easy tin supply in 1948.

PAINT PRICES TO KEEP UP—The chances for a drop in price in paints and other finishing materials is not encouraging for the near future. The raw materials entering into their manufacture, especially oils and pigments, are expected to remain in tight supply all during 1948, and as long as the supply is below demand the upward price trend on these raw materials is likely to continue. Use and production of castor oil have dropped as linseed oil became more available, so that the general supply balance has not improved greatly. The dreams of last year for a big supply of titanium oxide to replace the scarce white lead pigment have not materialized so far, and great quantities of lead are still disappearing into pigment use. But paints for general uses are averaging much better in quality than during the war, and price should not be the determining factor in use.

(Continued on page 5)

A "Brush-Up" Booklet you'll want for your desk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(Continued from page 3)

PLASTIC AUTOMOBILE TOPS—Automotive industry leaders are said to be considering the use of colored plastic body tops for convertible coupes. If this move takes place it will probably mean an important new outlet for acrylic-type plastics.

IMPROVED LIGHT METALS ON WAY—One important manufacturing company has had some remarkable success in its laboratory with aluminum casting alloys containing beryllium. It is known that the Germans used most of their small supply of beryllium during the war for producing beryllium-aluminum master alloy. Small additions of this master alloy to aluminum and magnesium alloys gave better casting qualities, but tests now also show increased tensile strengths in the light alloys with small additions of beryllium. Beryllium is still a scarce and costly metal, although the ores are fairly plentiful. We are going to hear more about beryllium some day soon. Titanium is another element that in small additions increases the physical properties of light alloys, and it has been used with good results in hard and strong aluminum-zinc alloys. Titanium is on its way to becoming a plentiful and low cost metal.

MORE SYNTHETIC RUBBER USED—Less than a year ago the experts in Washington were trying to get Congress to permit the government to compel industry to use a definite amount of synthetic rubber in proportion to all natural rubber employed. The idea was supposed to be a national defense measure as it was thought that the production of synthetic rubber would be abandoned unless industry was forced to use it. The guess was wrong. The amount of synthetic rubber used in 1947 was far above the total proposed for use by the let's-have-a-law economists. Actually, because of poor guessing some government plants were closed, resulting in a present shortage of GR-S synthetic rubber. Rubber goods manufacture in 1948 will be at a high level, and mechanical rubber goods are taking more synthetic in the mixtures than was conjectured. A host of new industrial uses have also opened for sponge rubbers, and these are made from synthetic as well as from natural latex.

MORE DIE CASTING ZINC WANTED—Consumption of special high grade zinc by the die casters during 1947 was 220,000 tons, with 245,000 tons forecast for 1948—if they can get the zinc, according to the Die Casting Institute. As the new year begins the supply is tight again. Though there have been threats from time to time that aluminum for die castings might attain a higher percentage of the total than formerly, particularly if the threatened rise in zinc prices materializes, one must remember that aluminum, however, has also become scarce.

THINNER GAGE STEEL IN CARS?—The rumor is rife in Detroit that auto body builders are considering the use of thinner steel sheet in cars in the near future as a means of easing the steel supply situation. If this is true, the steel supply for industry in general would be increased proportionately.

IMPROVED METAL IMPORTS ANTICIPATED—Here is a new angle that may make a big improvement in the supply of metals and some other industrial materials in the not too distant future: Russia has been pursuing a policy of preclusive buying and diversion of materials to keep them away from western nations in order apparently to embarrass the west by shortages, such as the taking of Chinese tungsten that she did not need herself. The program has not been eminently successful. Now that Russia has large quantities of some materials above what she requires—chromium, manganese, lead, copper, and zinc—and is in great need of dollar credits to buy industrial equipment and also to at least make a token attempt to straighten out her lend-lease indebtedness, it is believed that as soon as she realizes that the Marshall Plan is going to be a success she will want to sell us raw materials in order to get the credits she must have.

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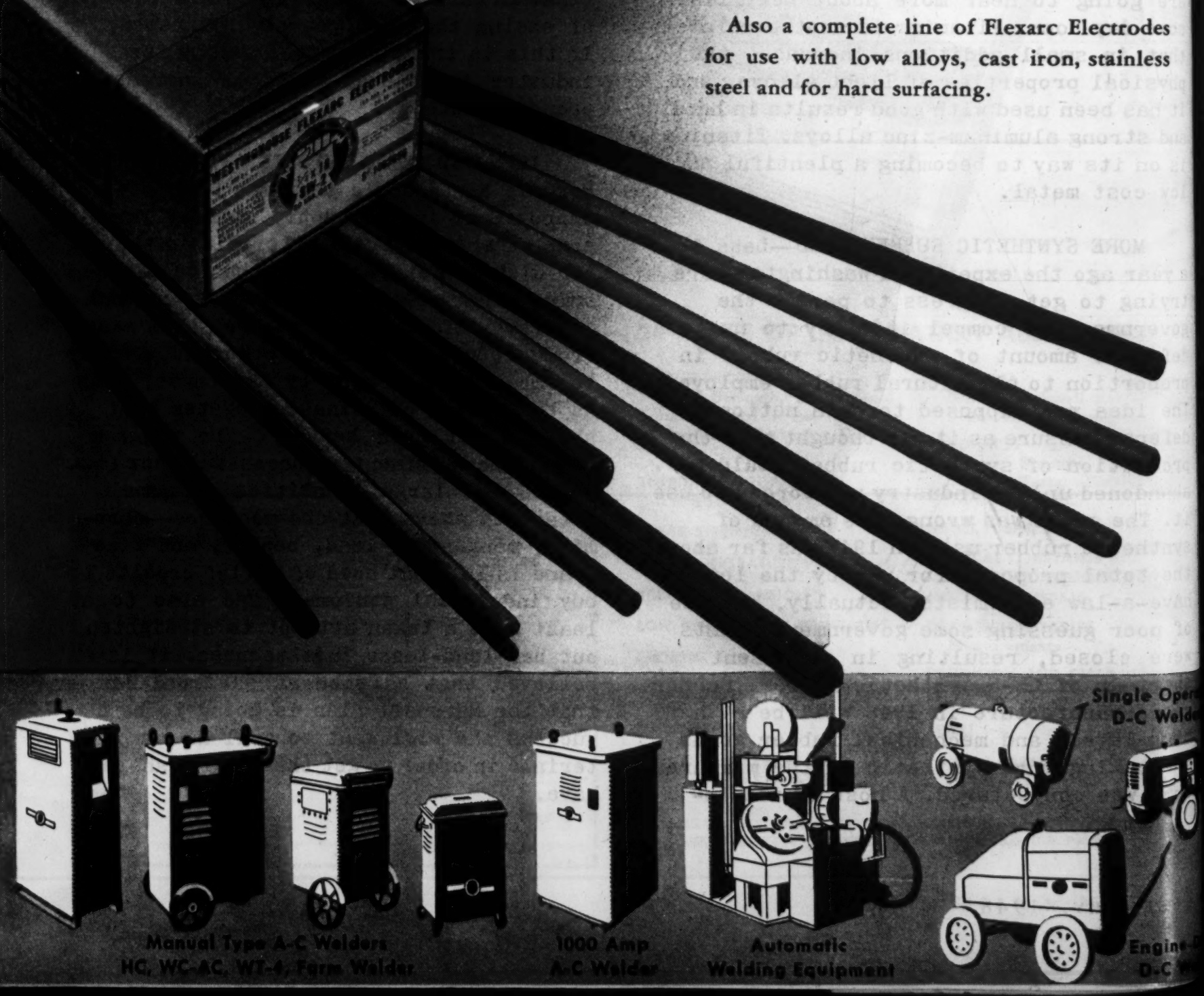

AN EDITORIAL

Who Wants War?

Take a canvass. Run a survey. Conduct a poll. Or just walk around with your ears open. No matter how you do it, you'll find that nobody—but nobody!—wants war. This includes people from the President, who presumably knows all about the situation, down to Mr. Average Citizen sweating it out with meat prices, taxes and a 1939 Ford.

Americans don't want war because they're happier and actually more prosperous at peace. Americans don't like to see people—themselves, other Americans or the people of other countries—get killed. Americans abhor the restriction and regimentation that fasten on everything when war comes. And Americans hate the heartbreak of war's hungry, homeless aftermath.

Russians, it must honestly be conceded, don't want war either. Another major conflict directly involving the Soviet Union now or in the near future would be disastrous for Russia's development. Whether the Russians have the same antipathy toward war involving others but not themselves is another question. But the important point is that Russia wants to do no warring of her own for a long, long while.

Nevertheless, there is a considerable "war fear" spreading in this country which is completely unjustified, except as it can itself bring us to the brink of war. What we have to fear is not war, since nobody dares or wishes to attack us, but the economic and political chaos which now threatens Europe and on which Communism will grow like a cancer, spreading ultimately to our own shores without the firing of a single battery.

This and not war is Russia's goal. And it is on this and not on war that we should concentrate all our present thought and effort!

For if we fail to rebuild Europe, no military establishment, however great, will protect us against the bloodless revolution that would eventually undermine our own structure, any more than the Maginot Line saved France in 1940. Indeed another war, toward which we are now drifting, would almost certainly be followed by confusion and Communism. But if we succeed in Europe, Communism will have received its worst setback, and we need thereafter worry no more about having to fight Russia to restrain her.

The Marshall Plan may bring added problems to materials men, for it will sharply intensify some existing shortages or postpone the day when supply overtakes demand. But these problems, like the financial costs of the plan, are small in comparison to those we would face during a war, when conservation and substitution completely dominate all materials engineering. It's a simple choice between a large investment of materials and money in peacetime reconstruction or a *colossal* investment of everything for war.

And, we ask again, who wants war?

FRED P. PETERS

Here's Coast-to-Coast Service on Alloys

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- Sheets and Strip Steel
- Tool Steel
- Wire, Chain
- Bolts, Rivets
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- Metal Working Tools & Machinery, etc.

RYERSON STEEL

Steel "Extras"— Why They Exist and How to Save on Them

by HAROLD A. KNIGHT, News Editor, Materials & Methods

DRASTIC REVISIONS IN STEEL "EXTRAS" during the past year have led the average steel purchaser to devote considerable attention to the new price setups and have caused metallurgists and engineers to reevaluate their needs with an eye toward using a less expensive form of steel to do a given job. In some cases they have found they had "used a man to do a boy's job." A recent typical case is that of a large company that wasted $1600 in buying 800 tons of steel by paying an unnecessary $2 per ton extra. There is a woeful lack of knowledge about extras. Thus, one steel maker reports that 30% of his orders come in without any specifications mentioned whatsoever. This high percentage may be due to the many new manufacturing concerns that have sprung up since the war.

The term, "extras," in this era of high-priced goods has a disagreeable connotation. In the automobile field it has often meant purchasing some extra accessories, not wanted by the purchaser, but necessary in view of the take-it-or-leave-it attitude of the dealer.

In the steel field, however, it is usually mandatory and desirable to pay a few extras on top of the base price in this age of tailor-made steel. It is the purpose of this article to outline the theory and practice of the extra system, particularly for the less experienced steel buyer, so that he can more intelligently make his purchases and avoid payment of unnecessary extras.

The system of extras just growed, like Topsy, over many years. Perhaps the word "differentials" would be a more agreeable sounding one than extras, since they actually are the differences between prices of various grades. The purpose of extras is to avoid having a tremendous catalog of steel prices for every conceivable size, grade, finish, weight, etc.

In early times, base prices were founded on the gage in greatest demand, or the one that represented most nearly the average gage weight. Many years ago the base gage on sheets was 28 gage, later changed to 24 and then 20 gage. Under that system there were usually extras and deductions. According to the present trend, the base price applies to the gage that is cheapest to produce, or perhaps most common in demand.

At the turn of the century the principal demand for sheets was for painted roofing and for the stove industry, with such typical grades as "Wellsville Polish," "Oakbody Steel," "Woods Refined," "Steamed Blued Sheets" and "Stove Pipe Iron." Then came open-hearth steel as a base sheet and pure iron arrived, permitting development of the enameling industry.

After 1910 the enameling and automobile industries required an entirely new line of sheet products, such as auto body steel, hood and fender steel, radiator casing steel, milk can steel, full pickled, full cold-rolled sheets and hot-rolled annealed pickled sheets. Starting with the late 1920's, further radical changes developed as a result of the advent of continuous hot strip sheet mills and cold reduction mills. Contemporaneously came radical changes in selling practices and in creating new grade terminology. Thus, special surface sheets became known as cold finish mill run sheets. During this rapid evolution "extras" changed radically and became more complex.

Though some call the 1947 revisions of extras "radical," they are mild by comparison with earlier evolution.

The More Common Extras

Among the common extras that apply to hot-rolled carbon bars, as examples, are: size of the bar (width, thickness or diameter); length (whether random or multiple lengths as-rolled, shorts permissible, or cut to specification); quantity (expressed in tons); quality (merchant or special bar quality); chemical requirements (content over base amounts of carbon, manganese, sulfur or silicon); non-standard specifications.

Alloy steel bars carry an additional set of extras, depending on: open-hearth or electric furnace practice; alloy content, or grade; special cutting; heat treatment; special straightness; extensometer tests; Magnaflux testing; centerless grinding; chamfering; etch tests; color marking; packaging; etc.

Formerly a great many extras had to be figured to arrive at the final sales price. Today the number of extras has been reduced to comparatively few unless the buyer orders quantities per item less than the weight of an ingot, or unless the flatness be other than commercial, the packaging different from standard, or some other special requirement is specified. For example, one producer of flat-rolled products finds that probably 80% of his tonnage is sold at base price, plus one extra for gage and size, plus freight from mill to destination.

Though extras may seem complex aplenty in steel bars, one of the more common forms of steel, they are A-B-C simple by comparison with wire products,

Table 1—Standard Product Classification

Bars, Plates, Hot Rolled Strip, Hot Rolled Sheets and Hot Rolled Annealed Sheets

Thickness, In.	Widths in In.				
	To 3½ Incl.	Over 3½ to 6	Over 6 to 12	Over 12 to 48	Over 48
0.2300 and Thicker	Bar	Bar	Plate	Plate	Plate
0.2299 to 0.2031	Bar	Bar	Strip	Sheet	Plate
0.2030 to 0.1800	Strip	Strip	Strip	Sheet	Plate
0.1799 to 0.0568	Strip	Strip	Strip	Sheet	Sheet
0.0567 to 0.0449	Strip	Strip	Sheet	Sheet	Sheet
0.0448 to 0.0344	Strip	Strip	H.R.A.	H.R.A.	H.R.A.
0.0343 to 0.0255	Strip	H.R.A.	H.R.A.	H.R.A.	H.R.A.
0.0254 and Thinner	H.R.A.	H.R.A.	H.R.A.	H.R.A.*	H.R.A.

**Except widths over 12 to 32 in. incl., thickness 0.0141 in. and thinner.*

It is important for the buyer to know whether his wanted flat-rolled item is a bar, plate, strip, etc. It largely depends on dimensions as seen by the accompanying table. (Courtesy: Carnegie-Illinois Steel Corp.)

where 70,000 items are made with a correspondingly large number of extras.

Extras are divided roughly into two classes: chemical and physical. An illustration of a chemical extra involves the common element carbon. Thus, for open hearth carbon steel plates any carbon content outside of 0.08 to 0.33 max. carbon carries an extra. Therefore, in specifying carbon content, it is important where possible to specify somewhere within this range rather than 0.35 max., the more common one.

An instance of the physical extra is specification A.S.T.M. -A-7-46, which calls for plates within definite tensile limits, carrying an extra of 5c per 100 lb.

The buyer must be posted as to when his flat-rolled product, for instance, is a sheet or a strip, a sheet or a plate, a flat bar or a plate. Thus, steel, 1 x 6 in., is a bar, but steel 1 x 6⅛ in. is a plate. Thus, if a 1 x 6-in. size were ordered to AISI 1020 specification, no extra for chemistry would be involved. However, a 1 x 6⅛-in. size is a plate classification, which carries a $1 per ton extra. Best, therefore, to use a size 1 x 6 or smaller, where possible.

It has often been stated in recent years that steel consumers are getting away from chemical specifications in favor of those pertaining to physical properties, such as tensile strength, hardenability, weldability, etc. This apparently must be taken with a grain of salt. One veteran steel salesman estimates percentages of specifications between these two types, from standpoint of number of orders, on common forms of open hearth carbon steel as follows:

Form	Physicals, %	Chemistry, %
Bars	10	90
Structurals	90	10
Bar Size Structurals	25	75
Plates	50	50
Sheets	5	95
Strips	10	90
Special Forms	5	95

Some specifications involve both chemistry and physical properties. Sometimes such combinations are acceptable, but often they result in considerable difficulty or misunderstanding. Every effort should be made to choose a standard chemical or a standard physical grade, thus avoiding a combination. This is cheaper and results in more prompt delivery.

Generally, chemical analysis is that taken from samples during the pouring of the molten steel into ingot molds, hence serves as only the average analysis of the finished products. The variation from piece to piece of finished product is represented by a "check analysis." As an example, assume the customer wants a carbon steel bar to A.S.T.M. A-7-46 specification. If he states: "Merchant bar quality, ASTM-A-7, check analysis waived," he will buy it at the base price. But suppose he orders; "Check analysis, as specified," he will be required to purchase special bar quality and pay 15c per 100 lb. more. However, other considerations, such as freedom from surface defects, may also require that this same higher quality be specified.

It is always safest to order check analysis procedure and variations on an A.I.S.I. basis. While A.S.T.M. A-107-46, A.A.R. EM-122-37 and SAE 1947 specifications coincide in some cases as to steel grade, in many cases they do not and unless modifications are made not only to grade but to check analysis procedures and variations, some serious additional extras may be involved.

Drastic Revisions in 1947

During 1947 there has been a substantial revision in extras, usually upward, but in some cases to the advantage of the buyer. It is plainly a sellers' market, and if ever perfect equity was to be attained it was dictated that it fall in this era. Unprofitable steel items tend not to be manufactured, to the distress of the consumer. During the era of price freezing by the OPA, for instance, it was found that several items

Table 2—Standard Product Classification by Size of Flat-Rolled Carbon Steel

Cold-Rolled

Widths, In.	Thicknesses, In.		
	0.2500 and Thicker	0.2499 to 0 0142	0.0141 and Thinner
To 12 Incl.	Bar	Strip[3]	Strip[3]
Over 12 to 24 Incl.	Strip[1]	Strip[1]	Strip[1]
Over 12 to 24 Incl.	Sheet[2]	Sheet[2]	Black Plate[2]
Over 24 to 32 Incl.	Sheet	Sheet	Black Plate
Over 32	Sheet	Sheet	Sheet

[1] *When a particular temper as defined in A.S.T.M. specification A 109, or a special edge, or special finish is specified.*
[2] *When no special temper, edge or finish is specified.*
[3] *When the width is greater than the thickness with a maximum width of ½ in. and a cross-sectional area not exceeding 0.05 sq. in., and the material has rolled or prepared edges, it is classified as* flat wire.

Table 2 corresponds with Table 1, except the flat products are cold-rolled. (Courtesy: Carnegie-Illinois Steel Corp.)

lost money for manufacturers, such items as galvanized sheets and wire nails, thus restricting the vital building industry. When free markets again prevailed, after the OPA's demise, it was only natural to raise prices to equal higher costs—and that meant raising base prices and extras.

One steel maker tells us that despite recent revisions, 20% of his products are under-priced in that profits in those items, if existent, are below average for the steel industry. He claims at the same time that none are over-priced. A large sheet maker ventures that 75% of his extras do not fully cover the actual extra costs of manufacture.

One maker opines that all commercial grades of carbon steel sheets are now under-priced—hot rolled, cold-rolled, enameling and galvanized steel sheets—and profit return is not as satisfactory as in 1940 to 1941. They contribute only 4% return on invested capital instead of the expected 6%.

The 1947 revision of extras has placed the entire price structure on a firmer, fairer and more tenable ground. It is to the advantage of the consumer that there is always a lag in raising extras to meet rising costs, whereas during a highly competitive market there is no lag, prices being cut early in the buyers' market era. Ordinarily, extras are not revised as often as base prices. Since the expiration of OPA, Carnegie-Illinois has revised extras on sheet four times; on bars, three times.

Typical Case History

From a questionnaire sent to steel makers, we learn that the average number of extras per order are three, and probably the three most common extras are those pertaining to size, cutting to length, and quantity. Let us see, therefore, what a typical order from Detroit for hot rolled carbon steel bars will cost the buyer—let us assume he is an automobile manufacturer, who will possibly insist on more than the average extras. The base price of these bars is $3.05 per 100 lb., delivered to Detroit. If the size he orders is in the range of 1½- to 1 5/16-in. dia., he need pay no extra on size. However, we'll assume he wants a bar 13/32 in. in dia. The extra is 55c per 100 lb. Let's consider, too, that he has specified grade AISI-1045 which is a common forging grade, involving a 10c extra.

Now considering quantity extras, if the auto maker buys 20 tons or over, he pays no extra. But let's assume that bars are used in a minor part on the country club model only, hence tonnage needed is between 5 and 10 tons. The extra will therefore be 10c per 100 lb.

As to length and cutting extras, up to 5 ft. long there is no extra as to length. Let's assume he wants the bars to arrive in lengths of 8 ft., the extra then is 5c for length and 10c for standard cutting. As to standard cutting, there is no extra, except on lengths of 5 to 10 ft. We'll say, too, that he wants bars of proper surface quality for forging, so he orders special bar quality at an extra of 15c.

The base price plus these extras figures $4.10, delivered Detroit. In short, about 30% of the total price of this typical order represents extras. One can hardly say, therefore, that the "tail wags the dog"—although it's a pretty big bushy tail at that!

In our questionnaire to steel producers we asked if each maker had his own individual schedule of extras or whether he followed the leader. Some of the more timid suggested that this was an impertinent or improper question to ask. The majority were more frank, however, and admitted that they copied the leader, as is the actuality in most industries where competition reduces prices to a common denominator. As an Ohio steel maker expressed it, they have their own distinctive sales policies but it is necessary to be "constantly alert" to the prices of competitors and, where necessary, adapt themselves to meet their rival's competition. A few remarked that on specialties they devised their own extras. Since the United States Steel Corp. is the largest producer of steel, it is only natural that their schedule of extras be followed industry-wide. Thus, when on Mar. 19, 1947 Carnegie-Illinois Steel Corp. issued a new list of extras on hot rolled carbon steel bars (which superseded its list of Feb. 17, 1947), it is safe to assume that other makers followed quite closely—otherwise there would be chaos, not only among the steel makers, but among the hundreds of thousands of consumers, who would not be able to quote intelligently on their finished products, not knowing the exact price of their steel.

There is a widespread but false belief that the American Iron & Steel Institute sets prices of extras. However, the well-informed realize that such is the farthest from the truth. By such action they would clash with anti-trust laws. What the Institute has performed is compilation of some two score or more steel products manuals, which describe various standards of steel. It is where specifications of the potential buyer differ from ordinary standard manufacturing practices that extras must be charged.

Thus, a typical manual is Section II, entitled

"Carbon Steel Sheets," the contents being divided into four parts: I, Definitions, Classifications and Manufacturing Practices for Uncoated and Coated Sheets; II, Chemical Practices; III, Gage-Weight Data for Uncoated Sheets—Standard Allowable Variations; IV, Standard Methods for Packaging, Loading and Shipping Flat and Coiled Sheets.

Besides hot-rolled steel products, there are standards for the cold-finished products, such as bars, strip, tin mill products, carbon steel wire and flat wire. All constructional alloy steels are classified separately, as are the stainless steels and tool steels. Electric furnace carbon steel is covered by the alloy standards. All steel tubular products, regardless of chemistry or finish, are covered under Section 18.

Offsetting Economies Enumerated

Recent advances in both base prices and extras, plus other mounting costs, have brought on a widespread campaign on the part of steel users to effect partially-offsetting economies, and in this the steel makers themselves are offering wholehearted cooperation. Steel salesmen are engineers and metallurgists as never before, advising use, where possible, of a cheaper grade of steel where it will suffice.

One method of offsetting is by using fewer varieties of steel in any one plant (See "Reducing Material Costs Through Standardization," MATERIALS & METHODS, Sept., 1947, p. 63). Another is by adopting processes that result in less scrap. Still another is by utilizing scrap that would in other years have gone back to the open hearth furnaces. Thus, one automobile maker welds together little pieces to make big ones, using them in some out-of-sight place such as underneath the car.

One steel company tries to save the customer money on the theory that a satisfied customer brings in more profits in the long run than where the selling policy is based on let-the-buyer-beware. The first question asked by the seller on an inquiry is: "What are you going to make with the steel?" "Will you deep draw it? Any special processing? Must it stand severe cold bending?" Important information for the steel producer would be the following as to bars: "To be forged and heat-treated, with pliers as the end product." The customer would then be advised to buy special bar quality.

Many people are reticent about revealing the end use for the steel, fearing that the seller is figuring on slapping another extra onto the base price. Customers are also advised to study the schedule of extras carefully to find loop holes and unexpected bargains.

Thus, low carbon steel plates for cold forming carried an extra for 0.15 max. carbon a short time ago. Now they can be purchased with carbon as low as 0.12 max. at no extra charge for "chemistry." Again, as to plates, you can still buy killed steel, in many cases a better plate, over 1½ in. thick, for the price of a non-killed plate, same thickness, at no extra cost—merely by specifying killed steel. Against a bar inquiry the sales manager asks whether he can't use a standard bar specification instead of a special, which results in a saving if the standard specification is acceptable.

In fact, in carbon steel plates there are three carbon specifications which are extremely useful and are affectionately dubbed "household words" by one prominent steel maker. They carry no chemical extras, but too often the buyer will demand some extra specification that adds to costs when one of these three would do as well. All are open-hearth steel, the first with carbon, 0.10 to 0.20, excellent for welding, and moderate cold forming; the second, 0.15 to 0.25 is good for welding, machining mild cold forming and structual strength; the third, with carbon 0.12 max., is designed for exceptional cold bending and welding.

Perhaps the steel consumer does not need a bar after all but can get along with a rod. A bar is more highly finished on the surface, more uniform in cross section and within closer tolerances, hence usually costs more than a rod, which has been rolled more rapidly and less precisely.

Can he use random or multiple lengths, to take 10% shorts or must each bar be cut to size, the latter entailing an extra? These are the kind of questions the consumer should ask himself, and thereby possibly save himself money.

Table 3—Size Extras

Carbon Steel Bars—Rounds, Squares, and Round Cornered Squares

Dimensions in In.	
1/4	1.30
9/32	1.10
5/16	.95
11/32	.75
23/64 to 13/32	.55
27/64 to 15/32	.45
31/64 to 35/64	.35
9/16 to 19/32	.25
39/64 to 47/64	.20
3/4 to 31/32	.15
1 to 1-15/32	.10
1-1/2 to 1-15/16	NONE
1-31/32 to 2-1/2	.10
2- 9/16 to 3-1/16	.20
3-1/8 to 4-1/2	.25
4-5/8 to 5	.35
5-1/8 to 5-1/2	.45
5-5/8 to 6	.55
6-1/8 to 6-1/2	.65
6-3/4 to 7-1/2	.75
7-3/4	.85
8	1.10

Table 3 gives extras, depending on size (dia. for rounds, length of sides for squares). Column at right expresses dollars, or cents, per 100 lb. The base price is here seen to be 1-1/2 to 1-15/16 in. (Courtesy: Carnegie-Illinois Steel Corp.)

Features of the New Extras

When the new and "radical" 1947 extras were issued, smart steel buyers studied the books on extras as never before. They indeed found some striking departures from past practices. Thus, the old popular carbon bar carburizing grade of C 1019 killed carbon

Table 4—Hot Rolled Sheets

PHYSICAL TEST REQUIREMENTS

When physical test properties or values, including tensile strength, yield point, elongation, Olsen, Erichsen or similar tests, are specified or required beyond commercial bend tests, the following extra applies: 0.25

When the seller is required to assume the double hazard for furnishing material to meet (a) physical tests, (b) drawing properties, the following extra applies: 0.35

HEAT TREATMENT EXTRAS

Gage	Normalizing or Box Annealing	Normalizing	Box Annealing	
			Maximum Carbon	
	Carbon, 0.30% Max. or Under	Carbon Over 0.30% Max.	Over 0.30% to 0.60%	Over 0.60%
12 and Heavier	0.25	0.25	0.25	0.50
13 and Lighter	0.25	0.35	0.35	0.65

SPHEROIDIZED ANNEALING—Box annealing extra, plus 0.15

DEEP DRAWING

Whenever deep drawing is specified or when the sheets must serve a severe drawing or forming requirement for which the supplier must stand a due hazard of breakage, the following extra will apply: 0.25

ROCKWELL HARDNESS

Commercial quality hot rolled or hot rolled pickled sheets may not be ordered to Rockwell hardness less than B 75 maximum. If a greater uniformity is required, then special heat treatment and inspection and selection will be necessary; therefore, hot rolled or hot rolled pickled sheets calling for Rockwell hardness to a lower maximum than B 75 can be accepted only with heat treatment extras for normalizing to apply. Orders calling for Rockwell hardness to within special and definite limits should be ordered in cold rolled sheets only.

The more special extras listed, as self-explained. (Courtesy: American Rolling Mill Co.)

steel, formerly at base price, suddenly carried a $7 ($3 for special bar quality, $3 for killed, and $1 for manganese) per ton extra. This extra reflected the once-disregarded fact that differences in cost of manufacture are substantial between killed, semi-killed and open effervescent (rimming) types.

Metallurgists agree, too, that as the carbon decreases, oxidation of the metal goes up, necessitating large amounts of deoxidizers, thus increasing costs. The former custom of increasing the selling price as the carbon content rose was based on tradition rather than studied fact. It is obvious, too, that the smaller the size, the more man-hours, power, and wear and tear on machinery are involved.

Other Considerations

Every time there is a radical change in extras (and this does not occur often) there is a shifting around of economies of manufacture among the makers. Often "what is one man's meat is another man's poison"—what is economical to make in a certain size, shape or quality for one mill at a certain base price plus extras may be undesirable business for another mill.

A common question is: How do the steel makers know just what extras in cents for 100 lb., or dollars per ton, to impose? The answer is, of course, that they know only approximately—hence, extras are usually in multiples of 5 points, or 5c, and not like department store pricings. Extras have, of course, evolved through the years, hence by study and instinct steel men know pretty well their costs, as determined by labor, power, raw materials, plant depreciation, etc.

In this era of high-cost labor such costs play an important role in determining what are base prices and what are extras. The product that can be produced with the fewest man-hours is naturally the cheapest. It is less costly to produce a wide plate than a narrow plate, because a larger tonnage passes through the mill in any given hour in the first instance. It is cheaper to produce a thick plate than a thin one, because the latter has to undergo more passes. Cold-rolling equipment is usually more expensive than hot-rolling. Wear and tear on machinery is faster with some types, such as forging, than with others, such as rolling.

Usually cost experts in each plant know of a few extras that are out of line in even what is regarded as a very superior extra set-up. Often, for instance, a sulfur extra was $3 per ton, but the actual cost was $5 because surface defects which are common to sulfurized steels had to be chipped out by expensive hand labor.

In conclusion, it is probable that the steel industry stands very high among industries in charging accurately for its products. There has been but little, if any, "by guess and by gob" methods of pricing. Examination of price changes in recent years will show that present steel prices would have to be increased by over 50% to equal the average advance since 1940 in wholesale prices of all commodities, and more than that to equal the individual advances of certain nonferrous metals.

Silicon Bronze Welding Problems Overcome Through Inert-Arc Method

by **PETER J. GURKLIS**, Superintendent Boiler Shop Dept., The Dow Chemical Co.

This article is based on data submitted to The James F. Lincoln Arc Welding Foundation by Mr. Gurklis in its recent Design-for-Progress Award Program.

SILICON BRONZE HAS BEEN most generally welded by the carbon arc process and satisfactory results have usually been obtained. However, it has been found that when moisture is present in the weld zone during welding, carbon arc welds are likely to contain excessive porosity which consequently lowers their strength and ductility. This moisture, if present in the base metal, can often be removed by preheating; and, by proper precautions, it can also be eliminated from the flux and filler metal. But where carbon arc welding is done in humid atmosphere, preheating is of no use and porosity is unavoidable. Under action of the arc, the moisture in the air breaks down into hydrogen and oxygen, and it is the presence of hydrogen during the fusion process that causes porosity.

This problem of moisture was encountered in the construction of chemical processing equipment, such as fractionating towers, heat exchangers, and pressure storage tanks. It was found that porosity could not be avoided in carbon arc welds made in an atmosphere with a humidity of about 65 grains or more moisture per lb. of air. Since the humidity in the shops fabricating the equipment was often above this figure, carbon arc welding was not satisfactory; so an experimental welding program was conducted to find a more suitable process for welding silicon bronze under these conditions.

The welding processes investigated were: (1) carbon arc, (2) shielded metallic arc, and (3) inert-gas-shielded arc using three different shielding gases—helium, argon, and nitrogen. The material used in the investigation was the same silicon bronze being used in the chemical processing equipment referred to previously. The material has a nominal composition of 96 copper, 3 silicon, and 1% manganese, and conforms to ASTM Spec. B96-52 for annealed plate. It has a tensile strength ranging from 50,000 to 67,000 psi. and a minimum elongation of 40% in a 2-in. gage length. The surface finish of the material is called "plain pickled" and is brick red in color due to the coating of cuprous and silicon dioxide.

Test Procedure

All welding was performed inside under reasonably close shop conditions. Since humidity was recognized as being an important factor, no special precautions were taken to weld under dry atmospheric conditions. However, no welding was performed during rainy weather.

The source of welding current for all test plates was a 400-amp. capacity, variable voltage, single operator, motor driven, welding machine. The welds were made in the downhand or flat position. However, welding in the vertical and overhead positions was also tried to determine the possibilities of each process for such applications. No data on this latter work are included in this report.

Although space does not permit giving the detailed welding procedures for each process, the accompany-

Summary of Welding Procedures

Welding Process	No. of Passes	Rod Dia., In.	Carbon or Tungsten Dia., In.	Current Amp.	Arc Volt
Carbon Arc	5 and 6	1/8, 5/32, 3/16, 1/4	1/4	140 to 180	28 to 40
Shielded Metallic Arc	5	1/8, 5/32	—	110 to 160	24 to 26
Inert-Gas-Shielded Arc, Helium Gas	5	5/32, 3/16, 1/4	5/32 and 1/8	260 to 300	26 to 33
Inert-Gas-Shielded Arc, Argon Gas	5	5/32, 3/16, 1/4	5/32 and 1/8	290 to 300	28 to 33
Inert-Gas-Shielded Arc, Nitrogen Gas	7	5/32, 3/16	1/8	110 to 150	35 to 40

Studies conducted to find the best method of welding silicon bronze under normal shop conditions yield results that should be helpful to any fabricator of this material.

Here the welder demonstrates the inert gas-shielded arc welding equipment and set-up used for the tests described.

ing table gives a broad summary to indicate in a general way the procedures used.

After welding, the weld reinforcement was removed. Although the specifications for the chemical processing equipment called for stress relieving after welding, the test plates were not subjected to the prescribed stress relieving treatment. Since stress relieving is generally considered to improve slightly the mechanical properties of the welds, the test welds were probably slightly "penalized."

The American Welding Society's Standard Qualification Procedure was adopted for making up the test plates and testing the specimens. The plates were ⅜ in. thick.

All welds were radiographed. After radiographing specimens for reduced section, tensile, guided bend, and free bend tests were prepared. In addition, nick-break fractures were made by sawing about ⅛-in. deep in the center of the weld and breaking the specimen "flatways."

In evaluating the test results on the welds made by the various welding processes under consideration, the requirements called for in the specifications for the chemical processing equipment were followed. These requirements are:

(1) Welds to be acceptable upon radiographic examination must meet the requirements prescribed in sub-paragraph (h) of Paragraph U-68 of the A.S.M.E. Code for Unfired Pressure Vessels.

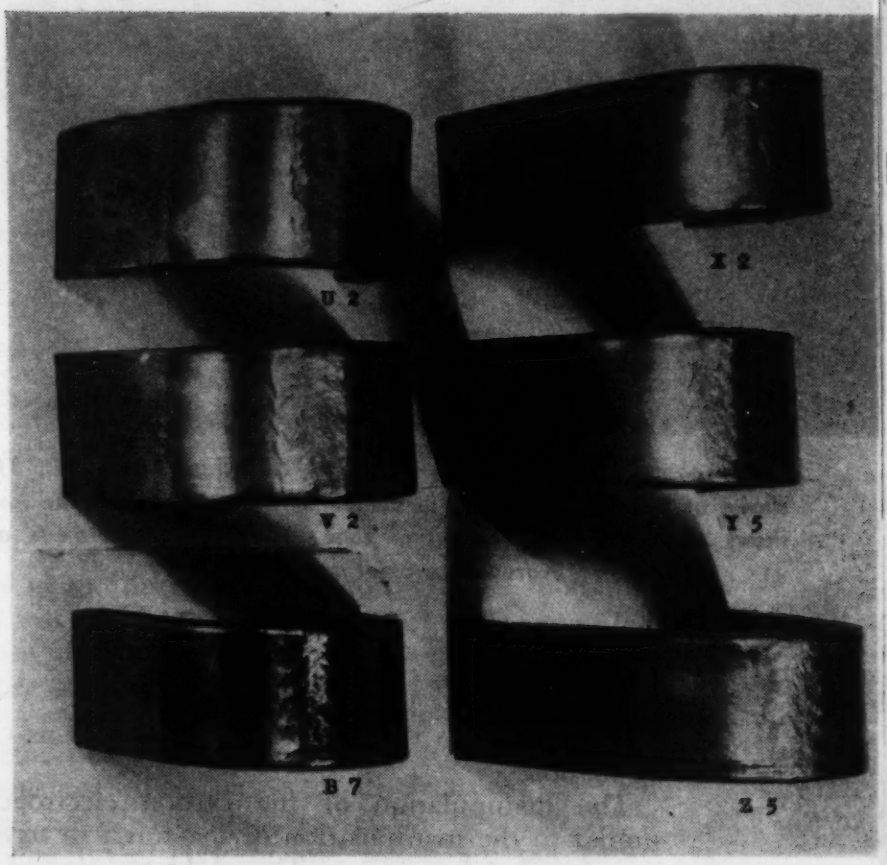
(2) Reduced section tensile strength must be 50,000 psi.

(3) Guided bend test specimens must meet the requirements of the A.W.S. Standard Qualification Procedure.

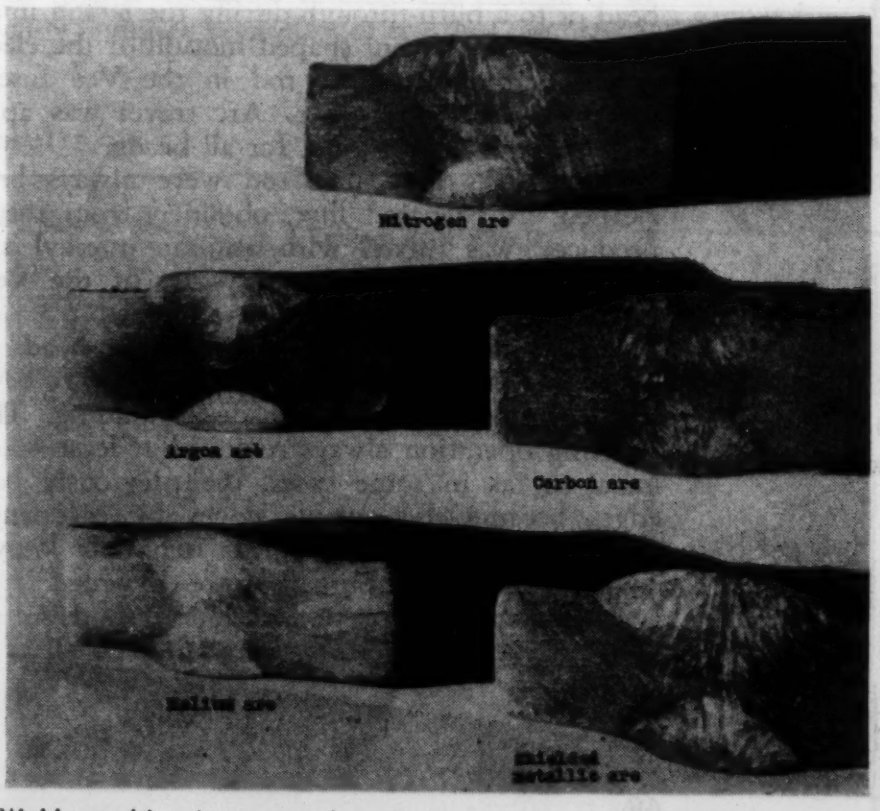
(4) In free bend specimens the elongation measured across approximately the entire weld must be at least 30% on the outer fibers.

Carbon Arc

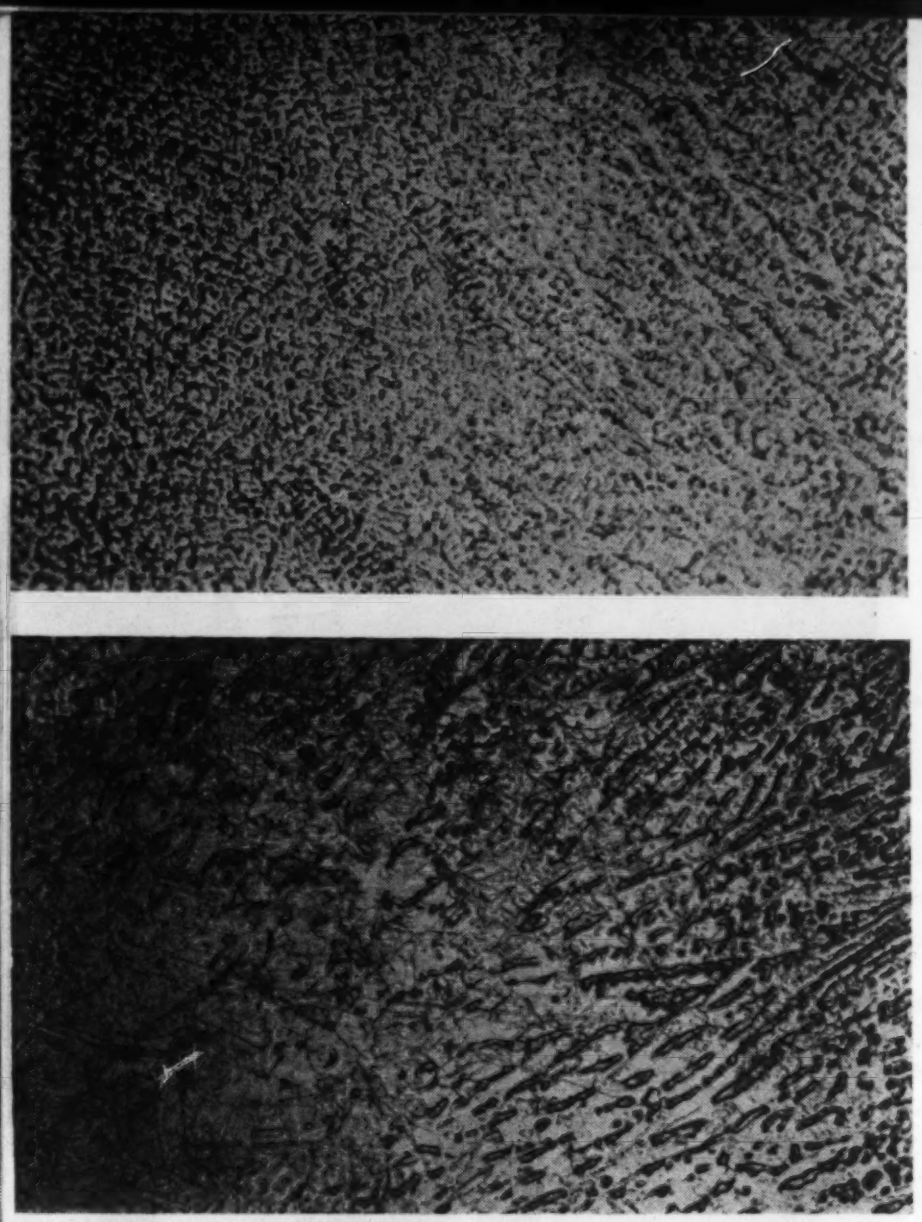
Every producer of silicon bronze plate has published welding instructions for his product. A study of this information revealed that there is wide divergence in opinion among producers in regard to the number of beads, rod diameters, carbon electrode diameters, currents and arc voltages for a given thickness of plate. In these tests the welding technique prescribed by the silicon bronze plate producer's welding engi-



These guided bend test specimens are considered as typical for each welding process.



Welds resulting from several methods of welding are shown in these photomacrographs. Specimens were given a ferric chloride etch, and magnification is about 3 dia.



These photomicrographs were made of a helium arc weld. That shown at the top is located in center of the weld, while the lower shows structure of the transition zone. (Ammonium hydroxide and hydrogen peroxide etch, 100X.)

neer assigned to the project was followed as closely as possible.

The manipulation of the carbon electrode was similar to the manipulation of the torch in oxyacetylene fore-hand welding. The weld progressed from the operator's right to his left. The filler rod was hardly moved except where it was necessary to supply extra metal to gouged-out spots in the underlying bead or to a burn-through during the laying in of the first bead. A crescent shaped motion of the electrode at the end of the filler rod in the Vee fused the component parts together. Arc travel was approximately 6 to 8 in. per min. for all beads.

Plate edges and filler rod were always brightly cleaned. A prepared flux, obtained from the plate producer, was mixed with absolute methyl alcohol and painted sparingly to the sides of the Vee for each bead. No back-up plates were used.

Porosity was usually found in the first bead. These plates were sent to the machine shop for re-beveling and then another attempt made at welding. The re-beveling operation always removed at least ¼ in. of metal or, as in some cases, the previously beveled edges became the outside edges by reversing the plates. Test plates which were definitely known to contain considerable porosity were discarded.

Radiographic inspection of the carbon arc welds revealed excessive porosity that rendered all of them unacceptable. The physical tests reveals that some carbon arc welds fulfilled the tensile strength requirements but failed in the bend tests. Free bend test specimens were obtained on only a few of the plates, because it was felt that for the time being the guided bend tests gave sufficient information in regard to ductility. The few guided bend test specimens that were tested passed; however, one specimen was a border-line case and this was from the best carbon arc weld in the experiment.

Shielded Metallic Arc

Silicon bronze is sometimes metallic arc welded with bare silicon bronze rod; however, the welding electrodes used in this work were heavily flux coated to provide a shielded arc.

Manipulation of the electrode was similar to that employed in mild steel welding with A.W.S.E.-6010 electrodes. Although this is somewhat an oversimplification, it indicates briefly the electrode manipulation. In actual practice the operator experiences difficulty in preventing slag inclusions. Fortunately, the tops of most of these defects were visible after brushing away the slag, thus enabling the operator to remove them by chipping. Attention is called to the fact that this characteristic must be taken into account because it will considerably decrease the output (footage per hr.) as compared with the output of the carbon arc and the inert-gas-shielded arc processes.

The radiographs for the shielded metallic arc welds were acceptable. The tensile specimens on one plate averaged 49,200 psi., but the other plates were well over the required 50,000 psi. All of the bend test specimens easily passed and revealed the weld metal to be ductile.

Inert - Gas - Shielded Arc

Compared with other fusion welding methods, the inert-gas-shielded arc is a newcomer in the trade. However, its merits and applications have already been extensively publicized. Commercial equipment, along with adequate information in regard to its use, is readily available at a price well within the means of even the small shop. An operator experienced in carbon arc or oxyacetylene welding can become proficient with the inert-gas torch with a day's practice.

In this investigation welds were made using helium, argon and nitrogen as shielding gases. Manipulation of the electrode and filler rod were identical with that described for carbon arc welding. Negative polarity was found to give the best results, although this does not apply for the welding of some other metals. The usual precautions in regard to cleanliness were observed, but no flux was used.

Previous experience with the use of argon showed that a smaller volume or rate of flow is required completely to envelop the arc as compared with helium. For all practical purposes here, it can be said that argon is ten times heavier than helium and it is about 25% heavier than air. Obviously, it has a natural tendency to "blanket" the welding zone.

The minimum required rate of gas flow is easily

determined by trial. The function of the gas is to displace the air that would otherwise be surrounding the arc. An insufficient flow of gas is detected by the burning of the tungsten electrode. In the case of the argon arc it can be said that a rate of gas flow sufficient to protect the electrode is the proper one for best economy. In the case of the helium arc, it is necessary to increase the rate of flow beyond this point in order to blanket the pool of molten metal. Wind drafts must be stopped or compensated for by an increase in the rate of gas flow.

In inert-gas arc welding the tungsten electrodes are gradually consumed although they do not become part of the joint. No implication is intended to the effect that with proper gas shielding the electrodes last permanently. Experimentation showed that, for this specific work and conditions, the flow rate for argon was approximately a fifth less than for helium.

The helium arc welds were X-rayed and all were found to be nearly perfect. These welds had tensile strength figures well above 50,000 psi., and their ductility enabled them to pass the bend tests.

Radiographic examination revealed the argon arc welds to be in the same class with the helium arc welds in regard to soundness, and, therefore, acceptable. The tensile strength was considerably above the requirements, and the bend tests showed the weld metal to possess the necessary ductility.

Nitrogen was used for shielding more as a scientific experiment than for anything else. It is called an inert gas and its price of 1c per cu. ft. is cheap compared with the 10c for argon or helium. These seemingly good points are erased by the fact that its inertness is not sufficient to withstand the electric arc. Manipulation of torch and filler rod were much like that used for the other gas-shielded arc processes. Even with a gas flow rate double that used for argon, the operator experienced difficulty in making the weld because of the rapid consumption of the tungsten electrode. It was later learned, from spectrographic analysis, that the tungsten passed into the weld metal.

Attention is called to the considerable variation in amperages used for the different welding processes. Except for the shielded metallic arc test plates, the welding speed or rate of arc travel was practically equal on all the test plates. The kind of gas surrounding the arc has a great influence upon the heating effect of a given amperage and arc length.

Radiographs of the nitrogen arc welds showed a complete and uniform dispersion throughout the weld of a substance that was opaque to X-rays. Spectrographic analysis proved this substance to be tungsten. Tensile strength of the specimens was good. The specimens also passed the guided bend test, but failed in the free bend tests.

Conclusion

The conclusion drawn from this investigation was that carbon arc welding employed under humid conditions, similar to that encountered in the tests, cannot produce welds in silicon bronze that will meet the requirements as stated above. Perhaps it can be demonstrated that with proper atmospheric conditions acceptable welds can be made. However, it is not practical for the weather to dictate shop schedules. Days having an absolute humidity of less than 65 grains per lb. of air are exceptional rather than the rule in the shops where this chemical processing equipment is fabricated. It was not economically feasible to air-condition the shops. Air-conditioned tents were believed to be impracticable. The welding process desired was one compatible with general boiler shop practice. Therefore, the carbon arc process was ruled out.

The tests also showed that nitrogen shielding of the arc is not effective enough to produce welds capable of fulfilling all of the requirements, therefore, it also was ruled out.

Finally, it was concluded that the shielded metallic arc process and the inert-gas-shielded arc process using helium or argon gas can produce the desired results. The helium arc and the argon arc processes are highly recommended. The flux coated electrodes for the shielded metallic arc process can be obtained for a reasonable price. Helium and argon are not cheap gases, but their use in this case brings the cost of arc welding only up to the cost level of oxyacetylene welding. Unquestionably, this is not out of line for the high quality of work desired and which is so consistently obtained regardless of weather conditions.

Summary of Test Results

Welding Process	Tensile Test		Free Bend Test Av. % Elongation	Guided Bend Test	Radiographic Results
	Tensile Strength, Av. Psi.	Elongation % in 2 In.			
Carbon Arc	39,000 to 52,950	12.0 to 25.0	23.4 Failed	Approx. 1/2 failed	Excessive porosity. Unacceptable
Shielded Metallic Arc	49,200 to 58,300	14.0 to 50.0	43.0	All O.K.	Acceptable
Helium Arc	56,450 to 58,150	30.0 to 42.0	34.5	All O.K.	Acceptable
Argon Arc	58,250 to 58,437	31.5 to 48.0	39.7	All O.K.	Acceptable
Nitrogen Arc	55,200	28.0 to 42.0	29.5 Failed	All O.K.	Uniform dispersion of tungsten throughout weld. Unacceptable

Lightness and Strength Combined in Metal-Wood Composites

by **KENNETH ROSE**, Engineering Editor, Materials & Methods

WHEN THE FIRST WOODEN LAMINATE was made by bonding together thin sheets of wood, a material with more uniform properties was obtained, so it was a logical development that metal should replace plies of wood when special properties were desired. Metal inlays were used in furniture for hundreds of years, but such inlays were usually mechanically fastened to the wood. Glues that would bond metal to wood securely had not then been produced.

About 25 years ago a casein-phenolic combination adhesive was developed that would form a strong bond to metals, and metal-faced plywood became a standard engineering material. Unfortunately, the casein adhesives were resoluble, and so were not suitable for use where immersion in water was a condition, or even where prolonged exposure to excessive moisture must be endured. Addition of phenolic materials to the formulation increased moisture resistance, but it was still necessary to protect the bond against moisture.

About 10 years ago the first combinations of rubber and phenolic resin were used in a new type of adhesive, and during the war these adhesives were developed to a high degree of efficiency. With the end of the war they have gone into production of metal-wood sheet and other standard forms, securely bonded into a composite material, and capable of being fabricated by techniques that make the composite suitable for use as an engineering material. The bond is so secure that thin composites may be formed in presses like metal to a surprising extent.

The metal-wood composites are available in a wide range of compositions. The metal can be sheet steel, plain, galvanized, or enamelled; aluminum or its alloys; stainless steel in several types; copper, and many other metals if their special properties are desired. The wood portion can be standard plywood, usually of fir, with a choice of thicknesses and of number of plies, and of methods of crossing the plies, or it can be a thin sheet of veneer, usually of one of the cabinet woods. Other choices include such modified woods as Masonite, or such other vegetable fiber boards as Insulite or Celotex.

The special attributes of the metal-wood combinations that are obtained by the combined material over those of either the wood or the metal alone may be considered as either or both of two advantages conferred upon the wood by the thin metal sheet: (1) The wood is protected from atmospheric conditions; and (2) the metal considerably augments the physical properties of the wood.

Protection from atmospheric conditions can be given wood by coating with paint, and this is usually done when wood is intended for outdoor use. The protection given by a thin, continuous sheet of metal is much more effective, however, and the wood now becomes a suitable material for outdoor architectural purposes, for the bodies or cabs of trucks, for the

Woods of many types team up with a wide variety of metals to provide composite materials that are used where a special combination of properties is desired.

Shown at left is a panel of Haskelite Ornametl molded into the shape required for the top door panel of the Chrysler Town and Country. The light portion is natural unfinished wood. (Right) A partition of aluminum-faced plywood is handled by two men as it is installed in a railway car. (Courtesy: Pullman-Standard Car Mfg. Co.)

sheathing of streamliner locomotives, and similar uses.

Improving the physical properties of the wood is not entirely a matter of increased strength. Improved formability is a valuable characteristic for many uses, and dimensional stability, which takes into account the protection of the wood from atmospheric conditions, is a deciding factor for other purposes.

Fulfill Many Requirements

Wood-metal composites are indicated as the material for a particular purpose when a combination of several requirements must be met. These might be listed as follows:

(1) *Dimensional stability plus the surface texture of wood.* A sheet of metal will have dimensional stability when used by itself, but it is frequently desired to combine this stability with the appearance of wood. As an example, a department store in Chicago used plywood as a sheathing for its escalators, but ran into difficulties because the long sheets of wood expanded during damp weather and buckled, or contracted during the winter season when the air in the building became warm and dry. After complaints of torn clothing because of rough edges on the panels had been received, the store installed metal-backed plywood, which did not change dimensions appreciably.

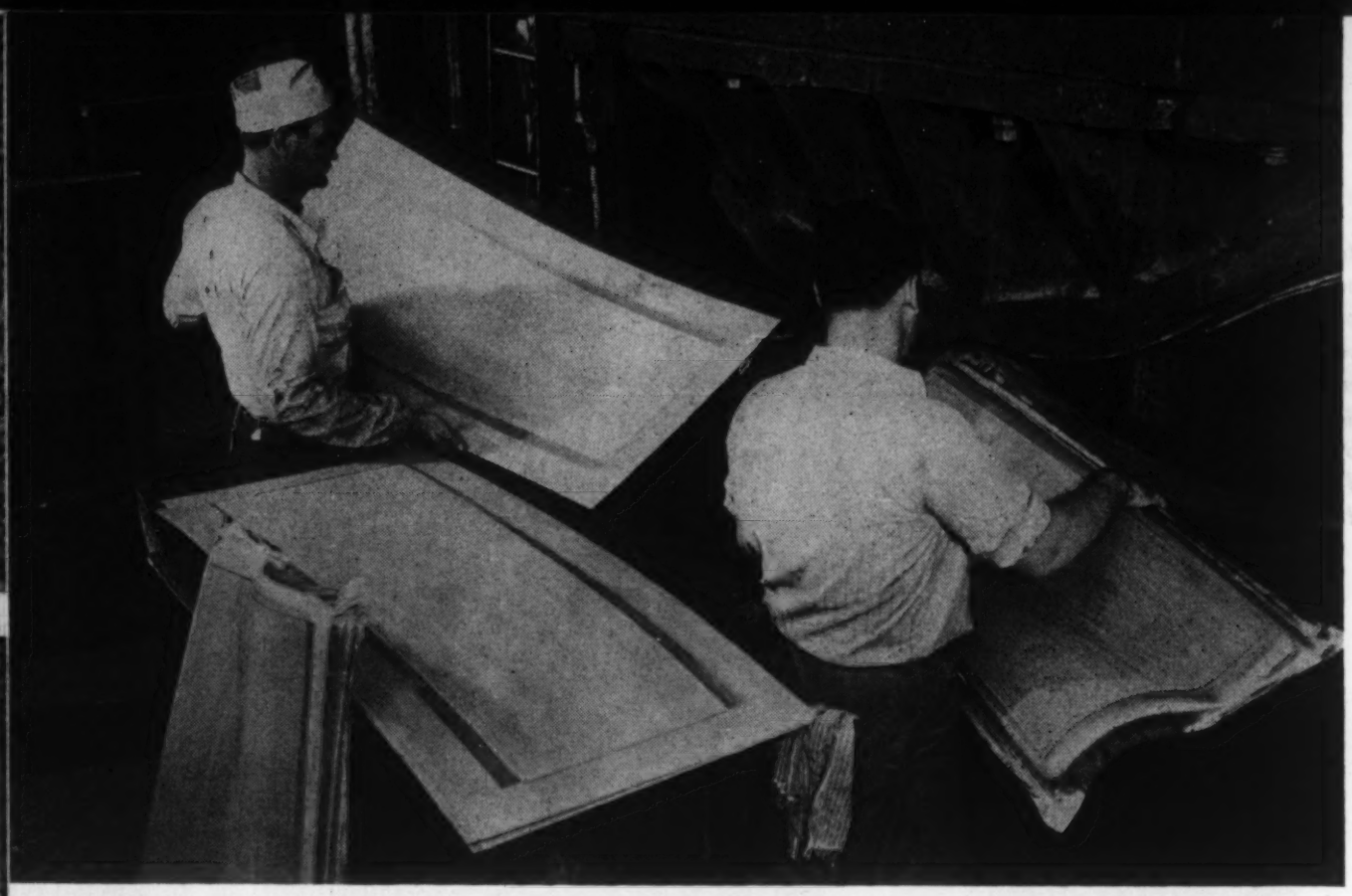
(2) *Light weight plus rigidity.* Metal alone may be made strong enough for many purposes, but if used in sheets of such dimensions that flexing will occur, the metal sheet must be stiffened if flexing, flutter, etc., are to be avoided. Framing adds weight, and becomes increasingly effective as the spacing of the frames becomes increasingly close. Backing the entire sheet of thin metal with another sheet of lighter-weight material is an ideal solution, and this is what is accomplished by using metal-faced plywood.

Uses in which the plywood backing is added to the metallic sheet to increase rigidity frequently overlap those given under (3). Thus, railway car partitions, doors, motor bus interior structures, and trolley car bulkheads use metal-faced plywood because of its combination of light weight, rigidity, and, frequently, bright metallic surface.

The newest member of the wood-metal composites, a honeycomb material in which plywood surface sheets are used to face a core of cells of aluminum foil, is also used for this set of requirements. Its high cost has limited its applications, for all practical purposes, to the aircraft industry, though there is a possibility that, with higher future production, the price may be reduced sufficiently to make the material practicable elsewhere.

(3) *Light weight plus metallic finish.* In some cases light weight is desirable, but a metallic surface, either bare or finished by one of the processes used with metals, is also wanted. The plywood sheet is here the primary material, and the metal facing, while it helps to carry the stress load, provides a surface that can be finished by painting, enamelling, etc., or used bare. This was the case in the construction of the shells of streamliner locomotives, for which a metallic surface was desired of its nonflammability, receptivity to paint, and resistance to abrasion. Fused enamel finishes may be used, if the steel is enamelled before bonding to the wood.

One of the most successful uses of metal-wood composites is in the adaptation of plywood sheets faced with aluminum or stainless steel to architectural trim, doors, railway car interior partitions, etc. Here the bare metal surface is desired, and the plywood



Automobile door panels of mahogany-faced steel are shaped in metalworking presses.

backing serves to reduce denting and increase stiffness without adding weight in proportion.

(4) *Formability plus the surface texture of wood.* Backing a thin sheet of wood with a sheet of metal permits a considerable degree of forming, especially forming between dies in metalworking presses. While no drawing is possible, the composite will take simple curves and a limited degree of compound curvature. The facing is usually one of the cabinet woods, and mahogany is favored. The most conspicuous use of this type of composite is in the new de luxe "suburban" automobiles, now in evidence everywhere as sports cars, and succeeding the station wagon in popularity. Chrysler Corp. has adopted the metal-backed wood sheet for door panels and rear deck on cars of this type. The composite is formed in metalworking presses, and the wood facing is finished by the usual methods to bring out the natural grain of the wood. The result is a panel that harmonizes with the remainder of the car, can be fabricated by modern mass production methods, and will retain its form when exposed to the weather.

(5) *Formability plus thermal insulating properties.* When the metal sheet is backed by a loosely-compacted board of bagasse or of wood fibers, the heat insulating properties of the board are supplemented by the strength and flexibility of the metal. This has been utilized in low-temperature storage cabinets, where the metal, frequently stainless steel, permits fabrication of the composite as a single operation. The heat insulating boards, because of the open texture that gives them their thermal qualities, are difficult to work by themselves, and to closely-fitting shapes.

A wood-metal composite, in which the metal is the insulating member and the wood provides lighter weight, is the lead-faced plywood used to give protection against radiation by X-rays or radium. In addition to these advantages, the composite sheet is easier to handle and to form. It may be placed in position like plywood, using special lead-topped nails when nailing is necessary.

Metal-Faced Building Board

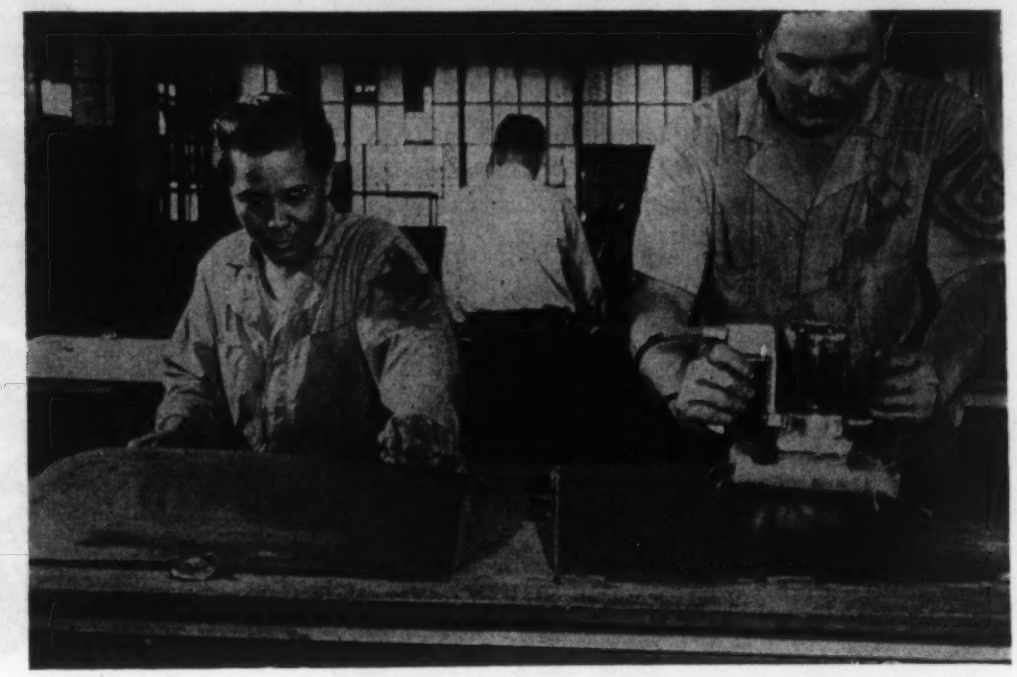
Recently an aluminum-faced building board was offered to the designers of prefabricated houses and to others. A test house of the material was set up in a southern region to determine its weatherability and general suitability for building purposes. The simplicity of construction possible with these metal-faced sheets, suitable for roof and sidewall, should appeal to persons interested in solving the housing problem. There has been considerable interest from tropical countries.

In the composites used today, by far the greatest portion use aluminum, stainless steel, or electrogalvanized steel as the metal component. Aluminum and stainless steel are much used in aircraft, railway cars, busses, and trolleys. About 80% of the new railway cars use metal-faced plywood for doors, partitions, or other interior fittings. A use that fortunately will not have long-time large-scale possibilities, but that at present is taking large quantities of aluminum-faced fir plywood, is the construction of burial shipment containers for the government.

For most of these applications the combination of light weight with adequate rigidity is the deciding factor in favor of the composite. It has been calculated that a sheet of the composite, faced on both sides with galvanized steel, will have a stiffness equal to that of a sheet of steel three times as heavy. This stiffness ratio will change over the range of sizes available, and with certain other conditions, but it is quite favorable to the composite whenever the dimensions of the unsupported sheet are large compared to its thickness.

Wide Range of Sizes Available

Composites are available in a wide range of sheet sizes and thicknesses. The wood-faced metal is produced in quite thin sheets, up to about 3/16 in., and may have a wood facing on one or both sides. Thicknesses may be made to order in a wider range of sizes.



After shaping, wood surface of composite material is finished like any piece of fine joiner work. (Courtesy: Chrysler Corp.)

The metal-faced plywood is produced in thicknesses of from about ¼ in. to about 2 in., with 4 ft. by 8 ft. the standard size for the sheet. Metal facings may be on one or both sides. Aluminum-cored honeycomb in general will be of the order of ¼ in. to 5 in. thick, with 4 ft. by 8 ft. the standard size of sheet.

The composites are more expensive than simple plywood or metal, on a comparable basis. Whereas ⅜-in. plywood, of fir, in quantity, will cost about 22c per sq. ft., the metal-faced material of the same thickness, with two sides covered with electrogalvanized steel, will be priced at approximately 35c. The honeycomb with aluminum core is sold on a cubic foot basis, but it is estimated that the price will be about $8 per cu. ft. after production reaches the volume stage, or approximating 65 to 70c per board ft. How increased production affects cost is brought out by a comparison of the cost of the new honeycomb with that of the first of these materials, made with a glass fiber core and first introduced about four or five years ago for use as a radar housing. It sold for about $100 per cu. ft.

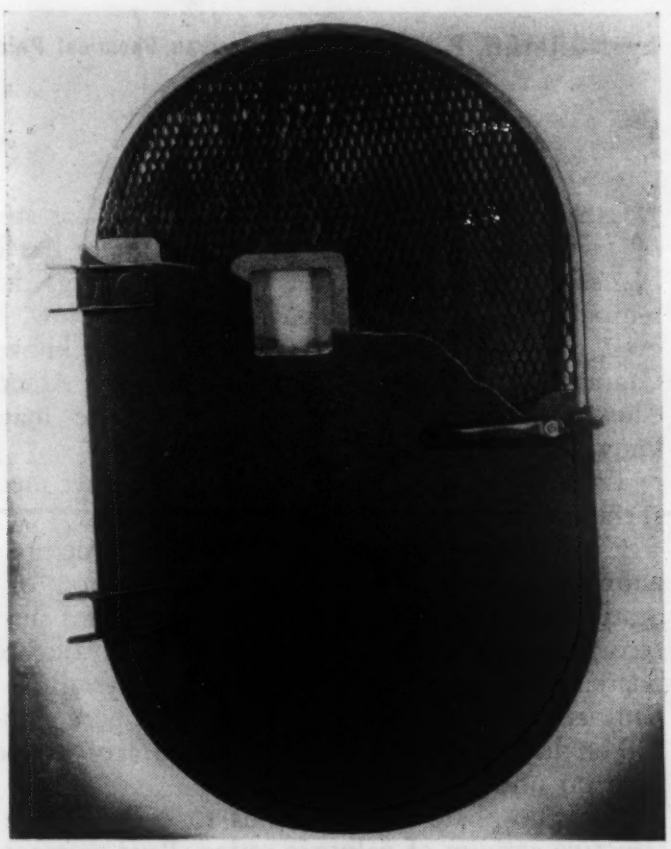
It is frequently possible to offset part of the higher cost of the composite material by savings in construction costs over simple sheets. Aluminum-faced plywood is more rigid than an aluminum sheet of the same weight, and therefore can be used in truck bodies with fewer framing members. For railway cars, a flush wall may be obtained with the metal-faced sheet by dovetailing it into aluminum extrusions, simplifying construction considerably.

The composite sheets may be sawn with metal-cutting saws, drilled, and, in the thin metal-backed sheets, formed in presses, as noted. Assembly methods include bolting, riveting, and sometimes soldering. In the case of the metal-covered plywood sheets intended for outdoor use, it is important that the metal barrier between the wood and the atmosphere be maintained, so exposed edges are carefully sealed over with the metal, and the edge made tight by soldering if service conditions are severe.

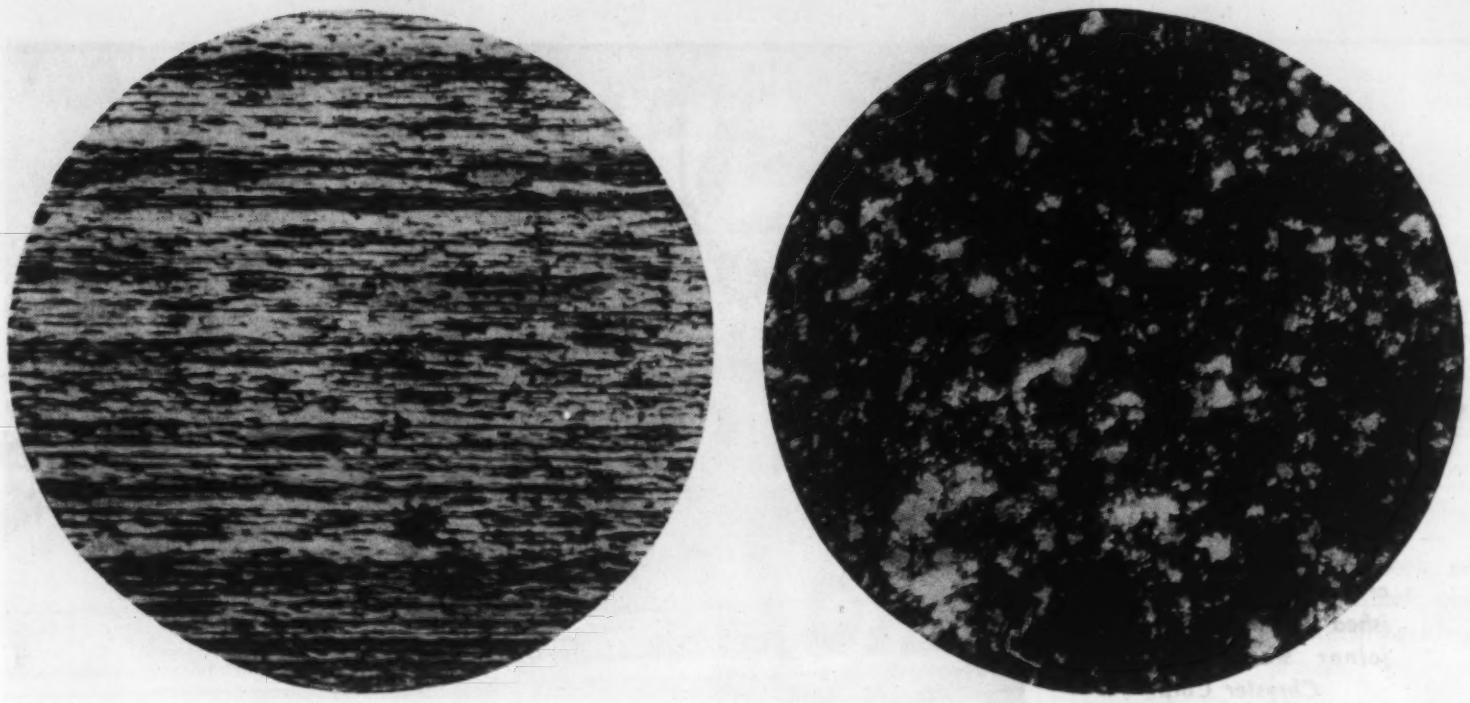
Qualities of the wood-metal composites that determine their use may be tabulated as follows:

Wood-faced metal
- (1) Dimensional stability
- (2) Formability

Metal-faced wood
- (1) Light weight with rigidity
- (2) Light weight with metallic finishing properties
- (3) Strength with heat insulating properties



Aluminum alloy is bonded to a honeycomb core in this airplane door which is strong and rigid, but light. (Courtesy: U. S. Plywood Corp.)



Granodizing changes the entire surface character of ferrous metal. The surface of untreated sheet (left) does not provide anchorage for organic finishes. The treated surface (right) provides a nonmetallic crystalline surface and grip for paints. (Magnification 100 X.)

Low Temperature Phosphate Coating for Steel Easily Applied

by **NORMAN P. GENTIEU, American Chemical Paint Co.**

THE VALUE OF PHOSPHATE COATINGS for steel is well recognized by industry, but there has been some restriction on use of these coatings due to temperatures required by most processes. Now, however, there is available a cold-spray process known as Granodizing. The process developed by American Chemical Paint Co. utilizes a phosphate material known as Granodine.

The use of Granodizing on steel and other metallic surfaces has several objectives and results.

First, the treatment alters both the structure and nature of the metallic surface. The action of the coating chemical on metallic iron transmutes the surface into a layer consisting essentially of zinc phosphate. This protective integument is crystalline and nonmetallic and is integrated with the parent metal.

The life of finishes over such surfaces is longer than on untreated steel.

The phosphate coating tends to suppress the destructive activity of galvanic action. Rust or corrosion is restricted to areas where accidental scratching, denting or chipping has exposed bare metal. The spread of rust or corrosion beyond the locale of damage is greatly inhibited and retarded by the presence of a phosphate bond under the paint finish.

The phosphate coating is uniformly structured. When paint is applied it flows into the regularly patterned interstices and is firmly anchored on drying.

It is in the actual process that Granodizing differs most from other methods of treating metal surfaces. The most important factor is that Granodizing is done at bath temperatures not exceeding 120 F.

Because of the small heat requirements, steam costs are reduced. Heat is usually required only in starting up a cold washer. Heat transferred from a hot cleaning solution, mainly by condensation, plus heat present in the plant is sufficient to maintain proper operating temperature in the Granodizing stage.

In addition to saving on steam costs, maintenance of steam coils is simple, since the small quantity of scale which forms on them is powdery and can be brushed off readily.

The process is extremely flexible in that the type of coating produced can be controlled. The coatings can vary from relatively thick, soft types to hard, thin types. Flexibility is due to the fact that rates

The cost of rust-proofing steel is reduced considerably through the use of a process which can be operated at low bath temperatures.

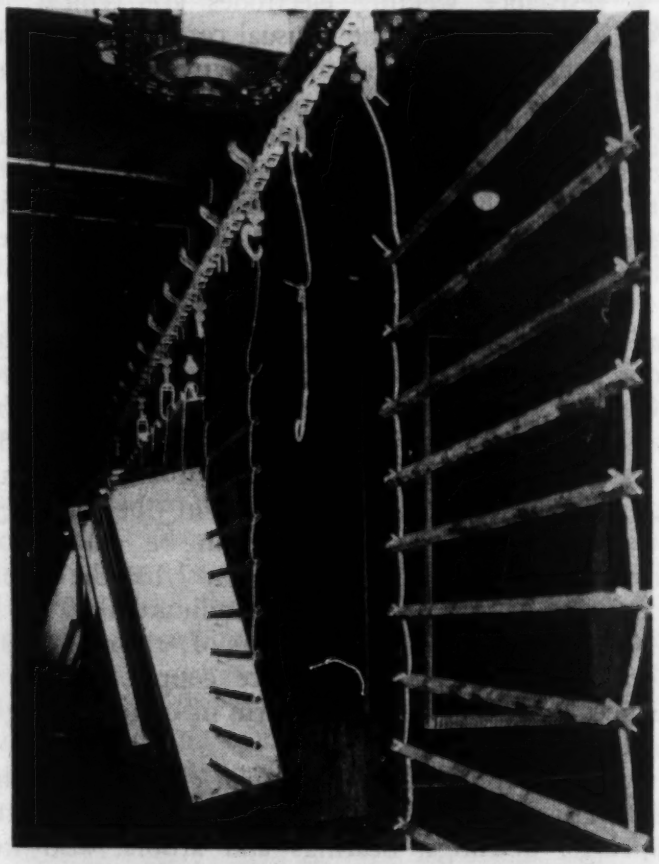
The panel on the left shows the effect of salt mist environment on an enameled but untreated panel. A treated panel on the right shows how rusting is confined to the scratch area.

of addition of the chemicals are under precise, individual control.

The solution is maintained supersaturated by continuous additions of metered quantities of a primer. Controlled quantities of the accelerating agent, hydrogen peroxide, are maintained by metered additions of a toner. The zinc phosphate content is maintained by metered additions of the zinc phosphate solution, Granodine.

Other advantages of the process include the fact that the solution does not give off rust stimulative vapors; sludge formed in the process is soft, minimizing clogged spray nozzles; chemical costs are low and operation is economical.

The production sequence of Granodizing involves five or six stages of processing in an automatic power spray washing machine through which the parts are carried on an overhead conveyor. A typical sequence follows: precleaning the metal by spraying with an alkaline-emulsion cleaner; rinsing with clean water (one or two stages); coating the metal with Granodine; rinsing with clean water; and, rinsing finally with acidulated water.



In this automatic setup, sheet steel refrigerator parts pass through cleaning, rinsing, phosphate-coating, rinsing and acidulated rinsing sprays. The photo was made in the plant of Seeger Refrigerator Co., St. Paul.

Trodaloy and its variations are filling the need for materials that are good electrical conductors and in addition can stand tough service conditions.

A New Group of Strong, Conductive Copper Alloys

by **HAROLD A. KNIGHT**, News Editor, **MATERIALS & METHODS**

SOME DOZEN OR SO types of equipment of which resistance welding electrodes are typical need alloys that have the unusual combination of high strength, high electrical conductivity, high endurance limits, high impact resistance and high service temperatures. In the case of the electrodes, two additional properties are demanded: Resistance to mushrooming, or high proportional limit, and an undefined property (the "X" property), which may prove to be surface contact resistance.

About ten years ago such an alloy, or rather two alloys, "Trodaloy 1" and "Trodaloy 7," were brought out by Dr. R. H. Harrington, research laboratory, General Electric Co., Schenectady, the name "Trodaloy" being a contraction of "electrode alloy." Both are precipitation-hardening alloys and both are usually furnished to the customer in the completely treated condition since both can be readily cold-formed in this condition. Trodaloy 1 has the nominal composition of: cobalt, 2.6; beryllium, 0.40%; balance copper. Trodaloy 7 consists of: chromium, 0.40; beryllium, 0.10%, and balance copper. These two alloys are obtainable in the form of castings, forgings and strip and wire.

Among applications other than electrodes are high strength (endurance) springs; electrically conducting springs, bushings, bearings and arbors; also items subjected to high temperatures, including springs, non-arcing contacts (such as in oil-filled circuit breakers, etc.), high heat-conducting brakes, soldering iron tips, high conductivity castings, motor blocks, and constructional castings. One very recent application is in replacement of conducting stainless steel parts in electric household irons.

In one instance Trodaloy 1 was the material for braided conductor for Bendix Eclipse brush conductors used in starters for airplane motors. The original lot of Trodaloy involved five tons in 0.003-in. dia. The alloy did very well and no failures were experienced by Eclipse, whereas OFHC (oxygen-free, high conductivity) copper gave rather serious trouble. The price of the Trodaloy was about ten times that of copper and its good performance was attributed to its thermal stability and high endurance. Finally, however, the failure of copper conductors was solved by redesign, hence Trodaloy is no longer used for that application.

In many of their properties the Trodaloys are comparable with, or even superior to, beryllium copper. The alloys are heat treatable. One develops its maximum properties by cold working after precipitation treatment whereas the other may be cold worked only in the solution-treated condition.

Several companies have been licensed to produce and sell this alloy. Thus, Wilbur B. Driver Co. makes and sells No. 1 under the trade name of "Beraloy C," in flat wire and some flat strip, this alloy supplementing Driver's other Beraloy line, cobalt-high beryllium and nickel-high beryllium, known as Beraloys A and B. These latter two are the standard ternary "copper-beryllium" alloys.

The Wilbur B. Driver Co. finds advantages of

Trodaloys were originally developed to meet the needs of resistance welders such as the machine in the Erie Works of General Electric Co.

Beraloy C (Trodaloy 1) in comparison with the ordinary beryllium coppers to be higher electrical conductivity, higher temperature of use (840 F), and ability to be formed in the heat-treated condition so that the material can be heat-treated by the manufacturer or supplier, and superior fatigue strength—both torsion and tension.

Similar Alloys

A variation from Trodaloy 1 is "Mallory 100," which contains silicon in addition to the other Trodaloy 1 elements. There are those who say that Trodaloy 1 has no true competitor. However, Trodaloy 7 has close competition from the Class II (as designated by Resistance Welders Manufacturers' Assn.) alloys: chromium, 0.80; silver 0.10%; balance copper; and chromium 0.80, tin 0.10%, etc., balance copper.

It may be in order here to mention a new alloy in the general class of Trodaloys, brought out by the Beryllium Corp., to which zirconium is added, being offered at a slightly lower price than the G. E. Trodaloys, yet the maker claims the same mechanical and electrical properties. Its composition: cobalt, 1.40 to 1.60; zirconium, 0.27 to 0.34; beryllium, 0.27 to 0.34%; copper, balance. It is also supplied in both solution-treated and precipitation hardened condition in three tempers: annealed, rolled 2 numbers and rolled 6 numbers, with minimum tensile strength after hardening, respectively, 105,000, 115,000 and 120,000 psi.

The General Electric Co. buys its alloys for use and fabrication of parts from licensed vendors. One licensee company, at least, Ampco Metal, Inc., make the sales point that they produce the alloys themselves and thus claim that they have a better control over them. They say further that through their close laboratory control they are able to obtain much higher electrical conductivity than is generally indicated with the recommended hardnesses in the various groups.

General Electric buys No. 1 Trodaloy materials from the following vendors: P. R. Mallory, Inc., under trade name of "Mallory 100;" Welding Sales & Engineering Co. (Tuffalloy 55); Ampo Metal, Inc. (Ampcoloy 91); SMS Corp. (Alloy W5) and Oakes Foundry Co. (Oakes Trodaloy 1); also strip and wire from the Beryllium Corp. (Berylcos 10 and 70); the H. A. Wilson Co. (Trodaloys 1 and 7), and the Wilbur B. Driver Co. (Beraloy C).

Trodaloy 1

	Castings	Forgings	Strip and Wire
Prop. limit, psi.	45,000	45-50,000	50-55,000
Elastic limit, psi.	50,000	50-55,000	55-60,000
Tensile strength, psi.	90,000	90-110,000	110-125,000
% elongation	10-15	10-15	8-15
Rockwell B hardness	92	92-98	96-108
% electrical conductivity	45	45-50	50-55
Impact (Charpy)	35 ft.-lb.	35 ft.-lb.	—
Endurance limit, psi.	30,000	30,000	34,000
Max. service temp.	840 F	840 F	840 F

Trodaloy 7

	Castings	Forgings	Strip and Wire
Prop. limit, psi.	18,000	30-35,000	35-40,000
Elastic limit, psi.	25,000	35-40,000	40-45,000
Tensile strength, psi.	40-50,000	55-65,000	60-70,000
% elongation	15-25	12-20	10-20
Rockwell B hardness	38-50	72-78	75-85
% electrical conductivity	68	72-75	72-75
Impact (Charpy)	45 ft.-lb.	45 ft.-lb.	—
Endurance limit, psi.	18,000	25,000	25,000
Max. service temp.	840 F	840 F	840 F

Properties of Trodaloys

Trodaloy 1 is equivalent to beryllium copper in proportional limit and elastic limit and far superior in conductivity, impact resistance and service temperature, while being slightly superior in endurance.

The No. 1 is very satisfactory for resistance welding the stainless steel evaporator in refrigerators, for example. The material is received by G. E. heat treated, and where desired in circular form, such as for a seam welder, it comes as a solid disk which the user machines to his own taste. Without this material it would be extremely difficult to fabricate stainless steel evaporators in the quantity needed. This material is hard, holds its shape under heat, which in automatic resistance welding operations, is very important.

Principal properties are: conductivity, 45% of that of copper; hardness, 96 Rockwell B, min. As to resistance welding of stainless steel, when Trodaloy was first introduced ten years ago spot welding electrodes consisted of: (a) pressed and sintered copper-tungsten powders, and (b) pressed and sintered silver-tungsten. The copper-tungsten faced spot welding electrodes had a life (on a specific application) of 150,000 spot welds, while the silver-tungsten ran 200,000 spot welds. Trodaloy 1 on this same application gave a life of 3,500,000 welds (with a purchase price about half that for the other materials).

The second special property of Trodaloy, important for resistance welding, is the "X" property (possibly surface contact resistance). For instance, in resistance welding of stainless steel, if 0.20% aluminum is substituted for 0.20% beryllium, in Trodaloy 1 the resulting alloy has identical tensile properties, electrical conductivity and resistance to temperature effects. But this alloy sticks to the material being welded and is therefore not suitable for resistance welding electrodes. Possibly the contact surface resistance is too high due, probably, to an oxide film.

Trodaloy 7, for wrought forms, is unusual in that, for maximum properties, it is cold reduced 45% *after* complete heat treatment at proper oversize.

Limitations

In comparing Trodaloy 1 with ordinary beryllium coppers, one of its users states that it cannot be heat-treated up to the same hardness and tensile strength, though it apparently has approximately an equivalent proportional limit. Its abrasion resistance is inferior. It is further stated that the alloy is more difficult to produce commercially and economically

Heat Treatment

Trodaloy 1	Castings	1 hr. 1650 F, water quench, age 2-4 hr. at 930 F
	Forgings	Same as for castings unless cold worked between quench and aging treatments as follows: 1 hr. 1650 F water quench, cold work not more than 45%, age 2-4 hr. at 905 F
	Strip and wire special	
Trodaloy 7	Castings	1 hr. 1650 F, water quench, age 2-4 hr. at 930 F
	Forgings	1 hr. 1650 F, water quench, age 2-4 hr. at 930 F and then finally cold work about 45% reduction
	Strip and wire special	
Both alloys are precipitation-hardening		

because of the great sensitivity and speed of intergranular oxidation. At the solution annealing temperatures the alloy must be protected in an absolute neutral or reducing atmosphere, free from water vapor and oxygen—easily accomplished in fine sections where sufficient quenching can be obtained by using high-conductivity cooled gases.

The same user started with billets received from a vendor and hot-rolled them to ¼-in. dia. and solution-annealed them, taking care to retain the hot mill scale as a protection against further intergranular attack. The rods were then pickled and drawn to 0.100-in. dia. From this point down the wire was solution-annealed in dry hydrogen and quenched continuously in cooled dry hydrogen. Above 0.100 in. a sufficiently fast quench could not be obtained in hydrogen.

While good, sound material was produced in the finer sizes, nevertheless, even with the above outlined precautions, some intergranular attack occurs in the bulk annealing of the hot-rolled rod. To remedy this, reverse die scalping was tried but the alloy did not lend itself to this method. But this user admitted that the alloy has some very attractive and beautiful properties, especially its retention of these properties at up to 840 F.

The General Electric sponsors do not try to dodge mention of its shortcomings. In speaking of strip and wire they point out that both Trodaloys—in fact, copper-beryllium alloys of under 1% beryllium content — develop intergranular oxidation when heated above 930 F in the presence of O_2CO_2, or water vapor. This permanently spoils strip and wire but is of absolutely no consequence on the surface of castings, forgings, plate or rod.

This intergranular corrosion penetrates from 1 to 5 mils below the surface and shows up as cracking, usually visible at 10 X magnification, when strip or wire is bent back upon itself (180 deg.) or around a mandrel.

However, it is pointed out that this oxidation can be prevented by carrying out all solution treatments (at 1650 F), intermediate to 45% cold reductions, and the final complete heat treatment, in an atmosphere entirely free from O_2CO_2, and water vapor (such as pure dried hydrogen, nitrogen, cracked ammonia, etc.). Even the quenching must be done in (a) a 10 NaCl, 10% NaOH (or the like) water solution, or (b) in a sharp cooling gradient in the proper gas atmosphere. This is neither the only nor the simplest method for avoiding intergranular oxidation, but it is the one that is most commonly available. Where serious difficulties are encountered it is usually a case of lack of proper equipment, or knowledge of how to operate it.

Comparatively recently the Beryllium Corp., Reading, Pa., has developed special heat-treating facilities, now in operation, to control the oxidation problem and they can meet the manufacturing specifications which call for no observable intergranular cracks at 25 dia. magnification when material is bent 90 deg. over a sharp corner.

While too lengthy for inclusion here, there are available complete data on Trodaloys covering the following: properties, compositions, heat-treatments, melting schedules, instructions for hot forging, hot extrusions, etc.; cold working; special data on strip and wire and patent coverage.

In spot welding the resistance of Trodaloy to mushrooming and its surface contact resistance make the alloy valuable for use on stainless steel.

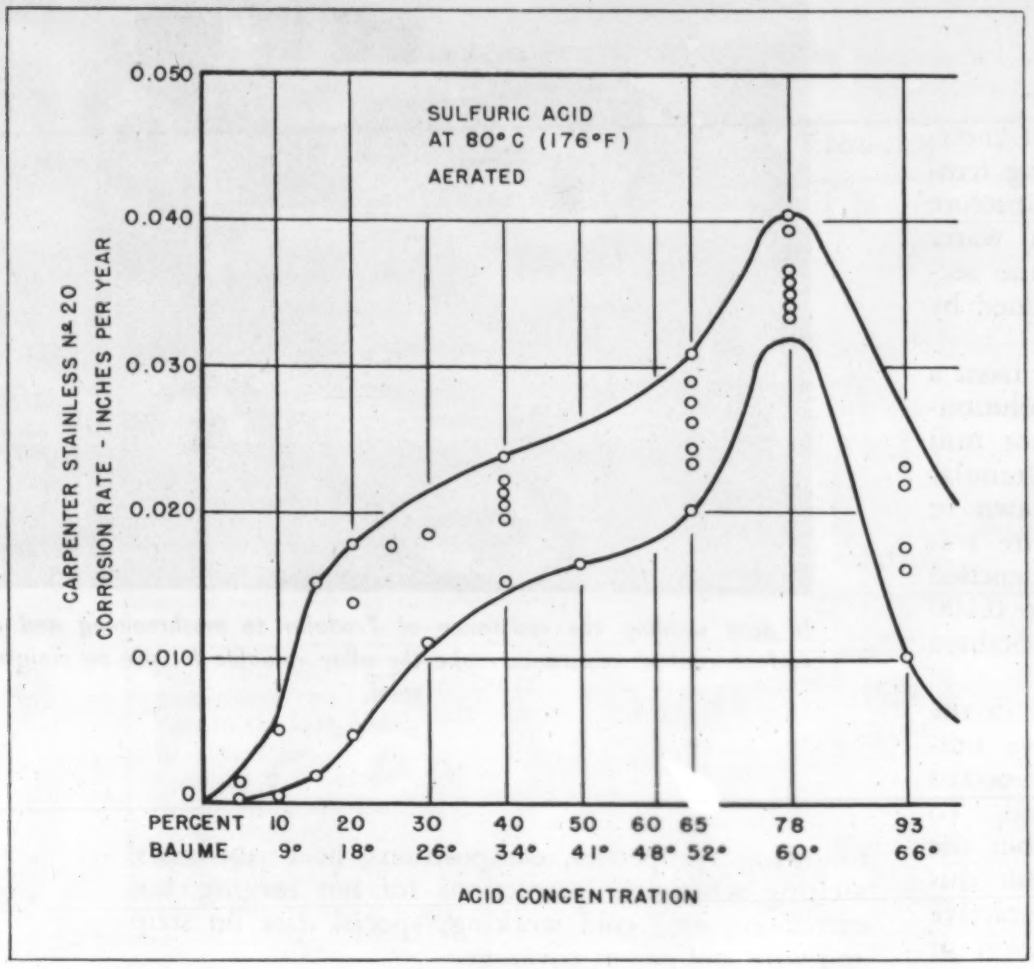
Economics of Use

In summary, the beryllium-cobalt-copper alloys offer a particular combination of properties not found in any other alloy, this combination being high electrical conductivity, resistance to elevated temperature and higher ductility for a given tensile strength than available in bronze, nickel alloys, steel and beryllium copper.

For usual spring applications Trodaloys offer no advantage over beryllium copper except for high operating temperatures, or where heavy electrical current must be carried and strength is not important. There is some dispute among experts as to what the safe temperature limit is, some claiming that the 840 F limit, mentioned by sponsors, is more accurately 350 F for any usable working stress. It is conceded by the skeptics that an extended time at 840 F would cause but little change in the material if it were under no stress—yet much the same could be said about many other materials such as over-aged beryllium copper.

There is but little advantage in making parts from unhardened Trodaloy strip. The fully hardened material has sufficiently good ductility to take most forming operations. This is the major advantage over beryllium copper. The latter has very much higher elastic limit, endurance strength and better ductility in the unhardened state. The tensile strength of full temper Trodaloy is 120,000 psi.; of beryllium copper, 190,000 and better.

Trodaloy would normally be specified for a spring application only when service temperature was high and working stress low, or where resistance to passage of current was more important than ability to work under high stress—or where that part was moderately stressed and it was an advantage to make the piece from fully hardened stock.



This graph shows the resistance to corrosion of sulfuric acid at a temperature of 176 F. The danger zone is in the range of 65 to 93% sulfuric acid as shown by the "hump."

Sulfuric Acid-Resistant Stainless Steel Now Available in Wrought Form

NEW MATERIALS PREVIEW

Many industries are expected to benefit from a highly corrosion-resistant stainless steel which is now produced as bar, wire, strip, tubing and pipe.

Until a few weeks ago Durimet 20, a "super corrosion-resistant" stainless steel made by the Duriron Co., was available only in cast form. Now through the development of new manufacturing techniques the material is available as bar stock, wire, strip, tubing and pipe. In these forms the wrought material, called Carpenter Stainless No. 20, is expected to be used extensively in the manufacture of heavy chemicals, organic chemicals, synthetic rubber, high octane gasoline, solvents, explosives, plastics and pharmaceuticals. Its outstanding characteristic is excellent resistance to the corrosive effects of sulfuric acid.

The Carpenter Steel Co. developed the processes for manufacturing the material in its new forms through an exclusive licensing arrangement with the

All types of chemical plants as well as refineries and producers of synthetic rubbers and plastics are expected to find wide use for the new forms of sulfuric acid-resistant stainless.

Duriron Co., thus the designation Carpenter Stainless No. 20. It is expected that some time in the future the material will be available in sheet and plate form.

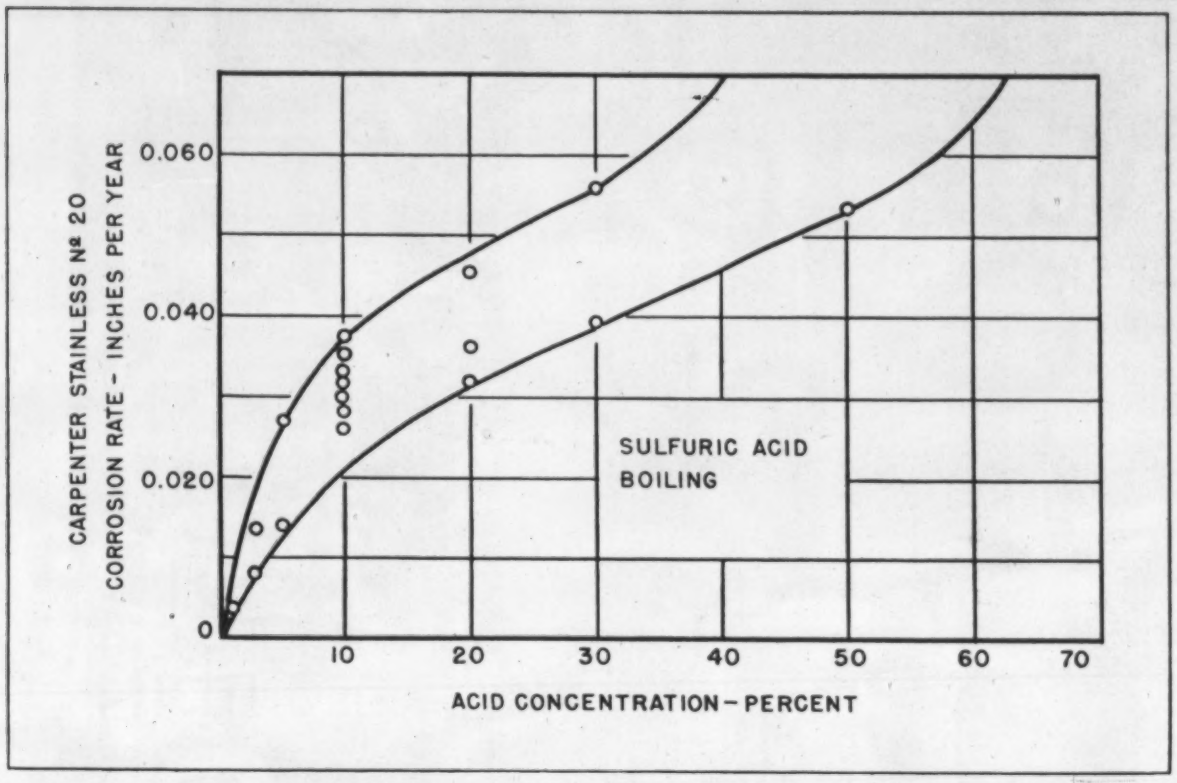
Composition of the alloy follows:

Carbon	0.07% max.
Manganese	0.75
Silicon	1.00
Chromium	20.00
Nickel	29.00
Molybdenum	2.00 min.
Copper	3.00 min.

The high nickel content in combination with high chromium and molybdenum keep the copper in

Properties of Carpenter Stainless No. 20

Mechanical	(Values Approximate)
Tensile Strength, Psi.	85,000 min.
Yield Strength, (0.2% Offset)	35,000 min.
Elongation, (% in 2 In.)	35 to 50%
Reduction of Area	50 to 70%
Hardness (Brinell)	150 to 180
Physical	
Specific Gravity	8.02
Weight, Lb. per Cu. In.	0.287
Specific Heat	0.12
Melting Point, Deg. F	2650
Thermal Conductivity, Cgs Units	0.05
Coefficient of Expansion (-68 to 1652 F)	10.31×10^{-6}



This graph shows the effect of boiling sulfuric acid upon corrosion rates of Carpenter Stainless No. 20. At room temperatures the acid has little effect on the metal.

solid solution, helping to attain the unusually good resistance to sulfuric acid. The austenitic matrix of the material has all of the mechanical properties of conventional 18:8 stainless. The 2% molybdenum content adds to the resistance to sulfuric acid, acetic acid and other chemical reagents.

Acid Resistance

As pointed out, the outstanding feature of the new stainless is the fact that it resists corrosion of 60 Be (78%) sulfuric acid solutions at temperatures in the neighborhood of 125 F. It can be used with 65 and 93% sulfuric acid solutions. Corrosion resistance of the alloy to various concentrations of the acid is shown in the accompanying chart.

Sulfuric acid solutions containing contaminants usually affect resistance of the material. The contaminants may act as inhibitors, accelerators or may have no effect. Inhibitors are generally oxidizing agents such as ferric sulfate, copper sulfate or nitric acid. The presence of 0.02% ferric sulfate so effectively inhibits corrosion that losses can be reduced as much as 100 times.

Carpenter Stainless No. 20 is especially resistant to nitric-sulfuric acid mixtures. The presence of any oxidizing agent will extend the limiting concentrations and temperatures for satisfactory service. When hydrochloric acid and certain halides are present in sulfuric acid mixtures, the corrosion rates are accelerated. The alloy is used extensively in equipment for sulfuric acid pickling of steel, but the addition of ordinary salt or other chlorides can materially shorten the life of the acid resistant parts.

Processing and Fabrication

The alloy is machinable, can be forged hot, is readily welded, and can be formed at room temperature. Its machinability compares favorably with that of Type 302 stainless. Forging requires careful control in heating.

Heat treating is not used to harden Carpenter Stainless No. 20. Water quenching to 2100 F results in maximum corrosion resistance. In the process of manufacture the material is given such a treatment. In common with other austenitic alloys, the alloy is subject to carbide precipitation when heated in or cooled slowly through the so-called sensitizing temperature range. For this reason, welded structures are given a subsequent water quench from a temperature of 2100 F. In the case of spot welding, where the time element is short, a final heat treatment is not necessary.

The material is produced in centerless ground bars which are shipped direct from mill stocks. Other forms available include: hot- and cold-rolled strip up to 8 in. wide and from 0.010 to 0.140 in. thick. In tubing it can be secured in sizes from ⅜ in. to 2⅜ in. O.D. and standard pipe sizes up to 2 in. The material also can be obtained in the form of welding rod and fittings from manufacturers of those items.

Experimental production of hot-rolled sheet 36 in. by 96 in. by 0.050 in. minimum thickness has proved satisfactory. Commercial production of such sheet is expected soon.

Many materials engineers are re-examining cast iron as a possibility for their products since it can be altered to provide a wide variety of physical and mechanical properties.

Cast Iron Offers Combination of Properties Not Found in Other Materials

by **NELSON G. MEAGLEY,** Assistant Chief Metallurgist, Willys-Overland Motors, Inc.

ALTHOUGH CAST IRON IS ONE OF OUR oldest engineering materials, there are many who are not familiar with the qualities of cast irons. Improvement in cast iron has kept pace with progress in other materials and so holds its own in any competition for applications. In fact, cast iron recently has regained some of the markets it lost temporarily to other materials and to other metal forms.

Today from 15 to 50% of a typical modern automobile is made of either gray or malleable iron castings. These materials are used not as substitutes for other metals but for properties or combinations of properties which no other material provides so well.

Cast iron has been called steel plus graphite. Consideration of this statement permits an understanding of the properties required for high strength cast iron. The graphite is in the form of small flakes and, being a weak constituent, the flakes can be considered as voids in a matrix of steel. In other words, cast iron is steel with small voids scattered throughout.

Therefore there are three considerations: (1) the amount of graphite (or voids); (2) the form of graphite, or the manner in which voids are located; and (3) the properties of the steel phase.

Graphite is the uncombined carbon in the analysis, and the less uncombined carbon, the fewer voids and the stronger the iron. Silicon causes the total carbon in the iron to separate into pearlite and graphite upon cooling so that the less silicon we have, the less graphite and the stronger the iron. Also, the more total carbon in the iron, the more will separate into graphite, therefore the less total carbon the stronger the iron.

The form of the graphite represents the form of the voids, and these are expressed in terms of A.S.T.M. charts prepared for that purpose. The length of the flake as seen at 100 diameters ranges from 4 in. or more in size 1 to ¼ in. or less in size 8. The distribution of the graphite ranges from uniform with random orientation in type A to inter-dendritic segregation, preferred orientation in type E. Highest strength irons have a small amount of graphite, and this is in size 1 and type A form.

The steel phase of the iron can, in general, be treated by steel metallurgy. The combined carbon is in the form of pearlite and adds proportionally to the strength of the iron. If, however, the cooling rate of the casting exceeds a critical speed, a high combined carbon will cause white iron, or hard, brittle steel, causing the casting to be difficult to machine.

Alloys are used in irons as tools of the foundryman, for the control of various properties. Chromium, molybdenum and other carbide formers decrease the graphitizing action of the silicon and, in addition, add

Table 1—Automotive Type Cast Iron
Physical Properties[1]

SAE No.	Hardness BHN	Transverse Lb., Min.	Deflection In., Min.	Tension Psi., Min.
110	187 Max.	1800	0.15	20,000
111	170-223	2200	0.20	30,000
120	187-241	2400	0.24	35,000
121	202-255	2600	0.27	40,000
122	217-269	2800	0.30	45,000

[1] *Properties determined from arbitration test bar (1.2-in. dia., broken on 18-in. supports).*

SAE 110 Miscellaneous soft iron castings (as cast or annealed) in which strength is not of primary consideration.
SAE 111 Small cylinder blocks, cylinder heads, air cooled cylinders, pistons, clutch plates, oil pump bodies, transmission cases, gear boxes, clutch housings, light weight brake drums, etc.
SAE 120 Automobile cylinder blocks, cylinder heads, flywheels, truck brake drums, cylinder sleeves, cylinder liners, pistons, etc.
SAE 121 Truck and tractor cylinder blocks and heads, heavy flywheels, tractor transmission cases, differential carrier castings, heavy gear boxes.
SAE 122 Diesel engine castings, liners, cylinders, pistons, and heavy parts in general.

Table 2—Typical Base Compositions
(Not Part of the Specification)

SAE No.	C Total	Si	Mn	S	P
110	3.40 3.70	2.80 2.30	0.50-0.80	0.12	0.25
111	3.25 3.50	2.30 2.00	0.60-0.90	0.12	0.20
120	3.20 3.40	2.20 1.90	0.60-0.90	0.12	0.15
121	3.10 3.30	2.10 1.80	0.60-0.90	0.12	0.12
122	3.00 3.20	2.10 1.80	0.70-1.00	0.10	0.10

These suggestions are offered with the thought that the producer will guard against either low-side or high-side for both carbon and silicon. If one is on the high side, the other should be low.

some strength to the steel matrix. Nickel, copper and other ferrite formers and strengtheners increase the action of the silicon but balance the chilling effect of chromium or molybdenum. Additions must be used with full consideration of molding and melting practice and geometry of any particular casting. To a large degree, alloys are tools used by the foundry to control their products in cooling to room temperature. In cast iron it is a growing practice to specify certain physical properties and to permit the foundry to adapt their melting and alloys so as to obtain these properties. We are speaking here of tensile strength only. There are additional considerations, such as corrosion and temperature resistance, where the type of alloy adds to the value of the product.

Engineering Properties

The quality of cast iron can be evaluated quite accurately from the chemical composition by the "carbon equivalent" formula:

$$C.E. = T.C. + \tfrac{1}{3}(Si + P)$$

C.E. is the carbon equivalent or quality rating. T.C. is total carbon, Si is silicon and P is phosphorus. The lower the carbon equivalent, the higher the hardness and mechanical properties.

Changes in the C.E. will alter the iron according to the following rules:

(1) Low C.E. irons have less change in hardness at different cooling rates.
(2) Low C.E. irons have less change in hardness in different section sizes.
(3) Low C.E. irons have higher hardness and tensile strength at the same cooling rate and section size.
(4) By varying the cooling rate or section size and with the C.E. constant, the tensile strength and Brinell hardness will vary directly.

Compressive Strength

The compressive strength of gray iron ranges from 70,000 to 170,000 psi. This exceeds almost all of the nonferrous alloys and is comparable to the best values obtainable with un-heat-treated alloy steel. Unlike steel, however, the compressive strength is not equal to the tensile strength, and if tensile loads are applied in service, these latter values must be used in design calculations. As the quality of the iron increases, the tension-compression ratio also increases—ranging from 1:4 for the weaker irons to 1:2.5 for the best high strength cast iron.

Hardness

Just as hardness is a measurement of tensile strength in steel, so it is in cast iron. In steel, however, hardness is also a measurement of compressive strength so that it can be used to calculate the reactions in bending moments. Also in steel, hardness can be used to estimate ductility. This is not possible in cast iron. Generally, hardness of cast iron will range from B.h.n. 150 to 269, although readings as low as 105 and as high as 600 are obtainable by special treatment in casting, alloying, and heat treating.

Wear Resistance

Many of the automotive applications of cast iron are found in its ability to resist wear. The graphite present in the structure serves as a lubricant between the frictional parts, and low seizure together with a low coefficient of friction result.

The following decreasing order of wear resistance is by F. G. Sefing:

(*A) Refined and completely pearlitic matrix—Type A graphite.
(B) Coarse pearlite matrix—Type A graphite.
(C) Pearlite with small amount of ferrite in the matrix. Type A graphite.
(D) Pearlite with small amount of cementite in the matrix. Type A graphite.
(E) Abundant free ferrite. Type A graphite.
(F) Abundant free cementite—graphite any type.
(G) Secondary ferritic matrix—dendritic graphite. Type D or E graphite.

*Minimum hardness for A is 190 to 200 B.h.n.

White iron provides high wear resistance without galling tendencies, and cast iron camshafts with flame hardened or chill cast lifts are widely used. Brake-drums are often heat treated to improve hardness and wear resistance. Nitriding of special analysis castings for automotive cylinder walls has been done to improve life of the bores.

When an oil film is present in a bearing, there is no wear on the metal. It is only when there is no lubricant or the film has broken that wear occurs; and it is under these conditions that cast iron finds one of its most valuable applications. Not only does cast iron wear well on other metals but it wears well upon itself.

Yield Point

Cast iron differs from steel in that there is no sharply defined yield point, proportional limit or elastic limit. At no section of the stress-strain diagram is a straight line found. Generally it can be assumed that cast iron will sustain a load of 80% of its tensile strength without perceptible creep, although a slight creep will occur at even small loads. This set can be greatly reduced by a few prior reversals of stress from zero to the operating load desired.

Ductility

Cast iron is a brittle material, and deformation before breaking cannot be allowed for in design. Strength in shock loading is generally low. However, a property not often considered is (due to the low modulus of elasticity) that the deflection in absorbing a given blow is more than twice that of steel. Work is the product of force and deflection, so then the actual force applied in impact is less than half that applied on a piece of steel similar in cross-section.

Modulus of Elasticity

The modulus of elasticity of cast iron is a function of the composition of the iron and the range of loading in which the test is made. There is no definite value. A reading is generally taken at 25% of the tensile strength to evaluate a particular iron and obtain comparable results. The modulus taken this way will range from 12,000,000 in the soft irons to 25,000,000 in the high test irons.

Damping Properties

Cast iron has the highest damping properties of any of the common engineering materials. The energy absorbed per cycle is in the range of ten times that of steel. This becomes a valuable property of such engineering structures as crankshafts, camshafts, flywheels, or any moving parts where a natural period of vibration can cause stresses far in excess of those determined by simple calculation.

Heat Resistance

Cast iron is affected by heat in two important ways. First, the material scales rapidly at high temperatures and second, growth occurs when the metal is subjected to atmospheric conditions at elevated temperatures. A limit of about 650 F is placed on gray iron, unalloyed. This can be increased to very high limits in alloy heat resistant grades.

At high temperatures, plain cast iron has poor properties relative to growth, scale resistance and strength. Below 600 F, temperatures generally not exceeded in automotive applications, the following relationship exists between temperature and physical properties:

(1) Short time tensile test, regardless of grade, is not affected.
(2) Endurance limit and hardness are about the same as at room temperature.
(3) As the temperature increases from room temperature, the modulus of elasticity drops slightly, about 20% at 600 F. Since the iron does not decrease in tensile strength, this represents an increase in elongation for a given load which, in turn, reduced the unit stress under impact. Shock resistance is improved as temperature raises.
(4) Wear resistance of iron at these temperatures is good, although there is a difficulty in correlating wear under these conditions.

Low Temperature Applications

Cast iron does not exhibit the low temperature brittleness found in steel. At temperatures as low as -100 F there is only a slight reduction in impact resistance.

Density

Since graphite has a specific gravity of approximately 2, there is a large volume change resulting from a relatively small amount of uncombined carbon. 3% uncombined carbon shows up as 30% graphite. This causes a reduction in the specific gravity of irons in respect to steels. The amount of graphite will determine the density and will range from 7.00 to 7.60.

Thermal Conductivity

Automotive cast iron includes a number of applications where a high heat transfer is required between combustion gases and cooling media, or between a bearing surface and the under metal. The thermal conductivity decreases with rising temperatures. At 750 F this can be expected to decrease to less than 0.100. Elements in the iron which combine with the ferrite, such as silicon, nickel, and manganese, tend to lower the conductivity while elements forming carbides do not have as pronounced an effect. Increased precipitation of the graphite increases the conductivity. A long anneal will have this effect, although the amount is slight. The more free ferrite and the less pearlite in the structure the better the conductivity.

Impact

Cast iron is not generally used to resist impact loading. Some irons, however, show surprisingly high impact values. In a broad way, the higher the tensile and the transverse deflection tests, the higher the impact properties.

Shear

Cast iron has a shear strength varying from the tensile strength in high strength iron to 1.6 times the tensile strength in the lower strength castings.

Coefficient of Expansion

The value generally taken for the coefficient of expansion of cast iron is 0.00001, which is twice that of steel. This figure is dependent upon the carbon content and temperature range, dropping 15% for carbon of the eutectic composition. Greater or less carbon increases the expansion.

Table 3—Residual and Alloy Ranges

	Ni	Mo	Cr	Cu	V
Permissible Residuals Base Iron, %	0-0.20	0-0.08	0-0.10	0-0.20	0-0.03
Recommended Ranges for Specification, Mean Specified Alloy Content, % Plus or Minus	0.15	0.075	0.10	0.10	0.03

When alloying elements are specified Table 3 gives the practical range for commercial limits.

Fatigue Strength and Notch Sensitivity

The fatigue strength of cast iron is approximately 50% of the tensile strength, which is similar to steel. The notch sensitivity, however, is much less than in steel.

Transverse Deflection

The standard test for the evaluation of cast iron is the transverse deflection test. A cast bar, generally 1.2 in. in dia., is broken by loading on supports 18 in. apart. The load required to fracture the bar, and the amount of deflection before failure, are taken as measure of the quality of the casting. A fairly good correlation is found between these values and the tensile strength. The engineering formula for mid-span loading cannot be used, however, since the modulus of elasticity is not constant in cast iron for all loads. This causes a shifting of the neutral axis and the compressive strength is not equal to the tensile strength. An additional value of this test is to determine the relationship between the tensile strength and the Brinell hardness. The high strength irons will give the lowest hardnesses for the high tensile strengths.

Thermal Shock

The principal consideration of thermal shock is in the specification of brakedrum irons. Surfaces are heated to temperatures above the critical in many of these applications. The strength must be such as to resist the resulting expansion and contractions.

Corrosion

At room temperatures, and under normal conditions, cast iron can be considered reasonably corrosion resistant. Under the application of dilute sulfuric acid and other corrosive media, such as can occur in gasoline engine cylinders, the corrosion rate increases considerably, and it is probable that this is reflected in the wear resistance of the metal in cylinder walls. A great deal of work is now being conducted in this field, and it is hoped that some definite conclusions can be reached in the near future.

Torque

The torsional strength of cast iron will range from 0.80 times the tensile strength for a hollow ring to 1.00 times the tensile strength for a round bar, and increasing up to 1.5 for square angle shapes. Not too much is known of this relationship. There seems to be no published literature where the torsional strength is less than the tensile strength in a solid section.

Working Characteristics of Cast Iron

Machinability

Cast iron ranges from one of the most machinable metals to one of the most difficult to machine. Standard gray iron, with a hardness of 156 B.h.n. and with the ferrite broken up by graphite flakes, is an excellent metal to cut. Generally, as the hardness increases, the problems of machining also increase.

The machinability of iron is considered a function of the tensile strength; the stronger the iron, the more difficult it is to cut. This is complicated, however, since much of the problem in machining the harder irons is due to the presence of chills on corners, thin sections and in scattered spots of the casting. The presence of alloys, such as nickel, copper, or combinations of chromium, molybdenum, or other inoculents, or even late ladle additions of silicon, will do much to relieve the presence of these chills. When these alloys are used to produce the casting, such as a cylinder block, it is possible to machine satisfactorily with the cylinder walls as high as 250 B.h.n.

The correlation between microstructure and machinability of cast iron is given in the following:

Ferritic Cast Iron. This is the lowest strength cast iron. High total carbon improves machinability; however, high silicon decreases machinability. Fine graphite flakes help while steadite will be injurious if it is excessive (as often are found in areas adjacent to shrink defects). In a scattered form and when not massive, the steadite constituent will have only a minor adverse effect on machinability.

Pearlitic Irons. Structures having a slight amount of pearlite with the balance of the matrix still ferrite give an increase in tensile strength and are more difficult to machine. Irons containing graphite, pearlite and no ferrite are considered high strength irons. With decreasing graphite, the strength increases and likewise, the machinability rating decreases.

White Iron. This iron is composed of pearlite and massive cementite, and the hardness is over 600 B.h.n. Machining is possible only by grinding. Mottled iron, composed of pearlite, free carbon and enough massive cementite to produce a mottled fracture can only be machined at slow speeds and feeds. Grinding is recommended when practical.

Usually machining difficulties in normal gray pearlitic irons are not caused by the typical structure of the casting, but rather to the presence of chills on corners, fins, thin sections and other locations favorable for the formation of white or mottled iron, and to the presence of imbedded sand, etc.

Weldability

Cast irons are weldable when special techniques are used. Arc or gas welds require a preheat and a post-heat operation, otherwise difficult machining and localized residual stresses will result. This is generally performed at approximately 1000 F and with a filler metal approximating the chemistry of the cast iron processed. A practice known as a cold weld employs a pure nickel welding rod (heated to a mushy temperature) which is deposited into the limited defective areas. These areas must be prepared by suitable cleaning such as grinding, drilling, etc.

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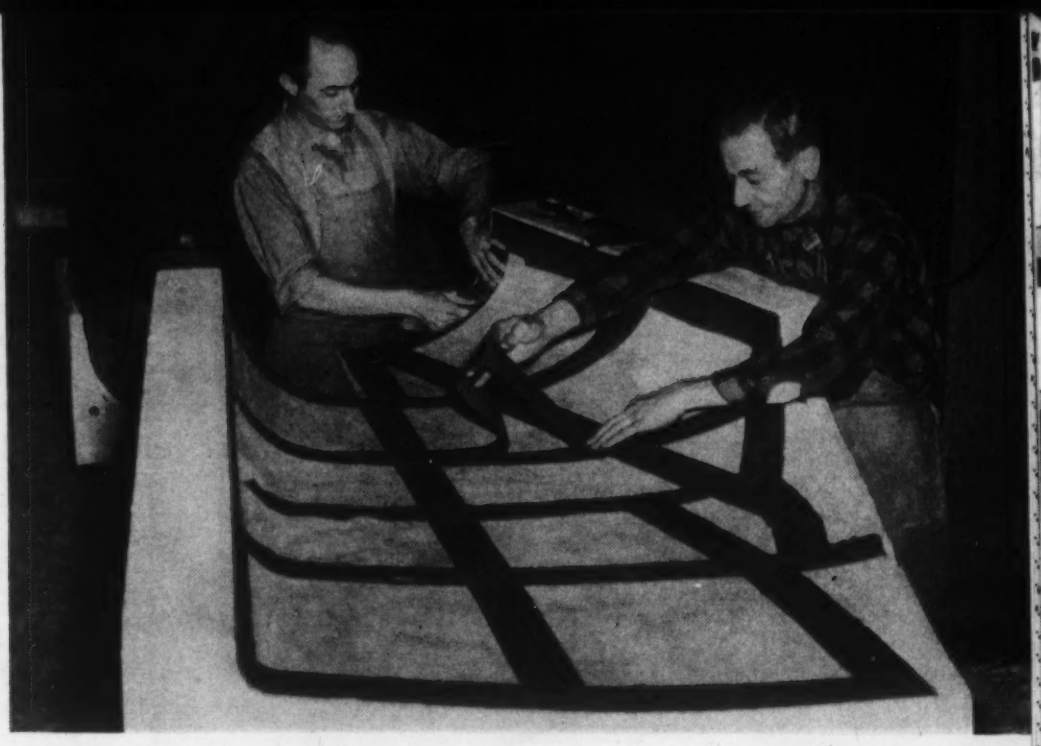


Here is a typical use of impregnated cloth strips to build up plastic tools. In this case a plaster mold is used.

Plastic Tooling
Strong, Inexpensive and Easy to Produce

by **LAWRENCE WITTMAN, Tool Development Engineer, Republic Aviation Corp.**

Laminated plastics can be used for forming tools, assembly fixtures, checking fixtures and many other types of tooling with few limitations as to size, shape and service conditions.

PLASTIC TOOLS IN THE FORM of low pressure molded—"cooked" to order—high strength laminates have been proved to possess a high degree of accuracy, stability, durability and permanency. The simplicity inherent in this method of producing a large class of tools results in substantially lowered tool costs and the greater utilization of unskilled personnel. In addition to economies achieved in tooling for full scale production, it is now possible to overcome the obstacle of limited budgets and thus provide good tooling for short-run operations.

Primarily, molded laminate tooling was developed for use in aircraft manufacturing, but it is by no means limited to that industry nor to sheet metal manufacturing alone. This system is applicable wherever special or project tooling is used to form, fabricate, check or hold components in position for various operations during the manufacturing process. This will especially hold true wherever such tools must incorporate complex shapes or contours.

Furthermore, it is now practical consistently to produce any number of duplicates of a tool which possess accuracy hitherto virtually impossible to attain with steel tooling. This feature will be of significance in dispersed plant operations requiring close coordination of tooling and where production volume necessitates duplicate tooling.

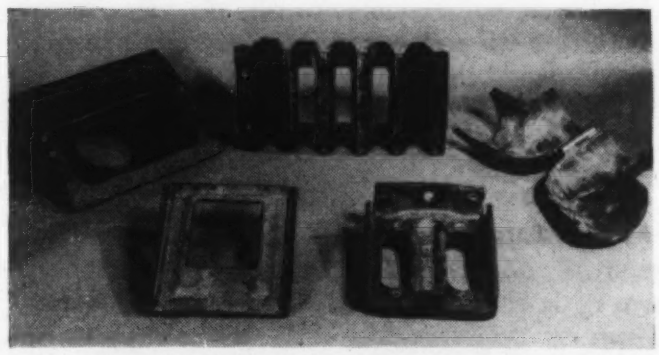
Obviously, the complete roster of tool types which can be satisfactorily handled with molded laminates will be available only after imagination and "know-how" have been applied to the tooling problems of many industries. At present, one can point to successful proved uses and later in this paper indicate additional immediate and future possibilities.

Included among the types of contoured fabricating tools now made exclusively of glass laminate at Republic Aviation are the following: checking fixtures, routing fixtures, drill jigs (drill nests, cages, bases), assembly, spotweld and installation fixtures. In addition, special tools, not in the category of jigs and fixtures, have been economically fabricated in this medium. Although these standard applications have been fully described in a previous paper[1], it is pertinent to mention and illustrate some of the more significant features.

Because of the light weight and relatively thin cross section, tool size, either small or large, does not impose any limitation on the use of the molding process. The contoured base of one large fixture is a single molding approximately 10 ft. long but it is

From a paper presented at the Annual Meeting, American Society of Mechanical Engineers, Dec. 4, 1947.

These are representative small contoured plastic tools.



Such shapes as these are easily produced in molded laminates.

by no means representative of the largest practical molding. The upper limit is determined by the facilities available—principally the size of the oven.

Where tool portability is required, the low weight of laminates becomes an important attribute. For instance, when routing fixtures were made of steel it was generally necessary to mount them on fixed bases and resort to less efficient hand routing methods.

There is, of course, no panacea for all tooling problems but, when wisely applied, molded laminates can be made an effective adjunct to, or improvement over, existing methods. The expansion of the application possibilities to a great variety of tooling depends upon a reorientation of the tooling man's thinking, at least to the extent of his admitting the possibility that other materials can serve as well as or better than steel. The demonstration that such is actually the case is the partial objective of this paper, along with discussion of design considerations and performance data.

Plastics as tooling materials merit consideration chiefly because they permit simplification of tool manufacture resulting in reduction of manufacturing time as well as lessening the requirements for and dependence upon highly skilled operators. A few of the many materials which were tested and used during the war years have found a limited place in the post-war economy. Through this development, based on the use of fully thermosetting type low-pressure resins combined with Fiberglas, it is possible to produce high strength tools for a wide range of application. Thus, molded laminates have proven in practice to be the best answer to the problem of tooling simplification, and with it plastic tooling has come of age, ready for recognition as a full fledged member of the tooling family.

With the development of practical procedures, low-pressure laminating techniques have been modified so that high quality results are consistently obtained. The final products are known as "molded laminates" to distinguish them from commercial flat sheet phenolic laminates also used in tooling.

Plaster, or simple formed sheet metal parts backed with plaster, are generally used as molds over which are placed multiple layers of resin impregnated Fiberglas cloth. After completing the layup, the mold is transferred to a portable molding table where a flexible vacuum bag or blanket is placed over it and the edges of the bag are fastened to the table to provide an airtight seal. A vacuum of 20 to 28 in. of mercury is maintained between the bag and the table throughout the cure of approximately 2 hr. in a 250 F hot air oven.

Evaluation of Molded Laminates

The principal economical advantage of this process is in molding the basic structure of a tool to shape and is derived from the simplicity and ease of molding compared to the difficulty and time consuming effort involved in fabricating conventional materials. Once the basic structure is molded and finished, the placement of steel drill guide bushings, clamps and other items requires no more time and skill than applying the same accessories to base structures made of steel.

In addition to the obvious economies, critical consideration was given to many questions which might possibly effect the successful large scale use of molded laminates in tooling. Typical of these were the following: Is it stable and rugged enough for permanent tooling? What accuracy can ve obtained? What are the costs as compared to conventional steel tooling? Can alterations and repairs be made easily? The answers are based on experience with over 1000 tools produced within the past two years and are hereinafter detailed.

Stability—One of the principal requirements of any tooling material is dimensional stability. In a laminate this property is a function of the reinforcing material and the resins used. Glass fiber, being of inorganic composition and non-cellular structure, meets this requirement since it is unaffected by normal humidity changes. This is one of the reasons why all tools, to date, have been made of glass cloth. The various types of non-woven glass mats should be equally suitable from this point of view, and their adoption is anticipated as soon as development is completed on methods of handling these materials in production.

The laminating resins, on the other hand, were subjected to greater scrutiny, in view of the previous experience with cast resins. The low pressure resins,

Accuracy, stability and low cost are features of such tools as this contour and trim line checking fixture.

because of their fully thermosetting nature and the absence of all volatiles, appeared to be free of adverse aging effects.

Two years' usage has proven this to be so, at least with respect to the resins employed at the author's plant. Since it is likely that other resins in the same family will behave as well, it is possible to base the choice of resins on such other characteristics as handling properties, shelf life of impregnated cloth, and over-all cost.

Accuracy—The most advantageous use of molded laminates is in the manufacture of tools involving complex shapes and contours. When similar tools are made of steels, a good contour or shape is obtained only through the expenditure of considerable hand work or machining time. Accurate reproduction of contour, on the other hand, is inherent in this molding process, since no noticeable shrinkage occurs in curing laminates. This is probably due to the low resin-glass ratio of approximately 30% by volume.

The minor springback encountered in some moderately contoured shapes can be minimized by proper lay-up, controlled heating and cooling, or readily overcome by simple external bracing. So far the last named method has sufficed in those cases where even a small amount of initial distortion could not be tolerated.

The retention of accuracy is naturally just as important as initial accuracy. Since glass fibre, and hence glass-plastic laminates, have no definite yield point, it is possible to work the material very close to its ultimate strength without permanent deformation. Thus, the accuracy of the tools is not impaired should they be accidentally dropped or temporarily overloaded. Such occurrences have often been known to cause deformation of steel tools.

Wear Resistance and Ruggedness—Again the properties imparted to the laminate by the presence of glass cloth as the filler material make these tools long wearing and rugged. Actual usage and tests have both shown that edgewise wear, as in router guide templates, is less on molded laminates than on normalized cold rolled steel.

Many tools are not only subject to hard usage, but are often misused. Tools must be rugged to survive such treatment. Due principally to the high impact properties of molded laminates, practically no breakdowns have been recorded to date.

Permanency—The previous observations regarding stability, accuracy, wear resistance and ruggedness lead to the conclusion that molded laminates can be expected to have long life and for that reason can be classed as permanent tooling materials.

Cost Comparison—All cost analyses have been made on the basis of comparing the laminated sections of tools to their counterparts made of steel exclusive of bushings and other accessories that may be required. As previously mentioned, the work involved in the installation of these accessories is the same irrespective of the type of basic structure employed. The actual cost of molded laminates is comprised of the sum of the costs of the mold, the molding and the trimming of the laminate.

It has been established that the average molded laminates can be manufactured in 60% less time than equivalent steel tools. The basic cost of materials is, however, considerably higher than steel. The higher cost is quickly absorbed by the man-hour savings and will become an even lesser factor as soon as lower

Low weight is a great advantage in such plastic tools as this 5-ft. long routing fixture.

This entire assembly fixture exclusive of clamps and mounting structure is molded as a unit.

cost materials and material saving methods, such as sandwich construction, can be further utilized.

The inherent cost saving features of this tooling system will become further evident after consideration of the following factors:

(1) The operations, in general, do not require the same type of skilled craftsmanship so necessary in the manufacture of most steel tools. This permits the utilization of less skilled operators.

(2) Production is readily streamlined by having separate sections of the plastic shop perform only certain specific operations. This makes for greater efficiency, faster production and more even flow of work through the shop. It is frequently impossible to break down steel toolmaking operations in such a manner.

(3) Each operation can be reduced to a limited number of steps of such nature that they do not generally call for the exercise of judgment or evaluation of the work on the part of the operator. Neither do they involve trial and error procedure. These things consume much time when fabricating steel. It is evident, therefore, that in a properly organized molding shop the pace is set mainly by the work and not by the worker. In short, there is no opportunity to while away hours massaging a piece of steel with file or hammer.

Reworkability (Alteration and Repair)—Although tools are expected to be permanent, it is frequently necessary to alter them in order to satisfy changes in product design or fabricating procedure. Moreover, any material, including steel, is subject to wear and damage under some conditions of use. The reworkability of any tooling material is, therefore, considered an important characteristic.

Alterations of both major and minor nature in the molded laminate tools are easily made and become an integral, equally strong, often indistinguishable, part of the original. Most alterations and repairs can be done at the bench using all-purpose, heated clamps to supply heat and pressure where necessary.

Major changes obviously call for the re-use of the mold so that the impregnated cloth can be layed over the proper areas and contours. In this type of rework, essentially the same steps are followed with respect to the use of vacuum bag for pressure and the oven for cure, as in the original molding process.

Application Possibilities

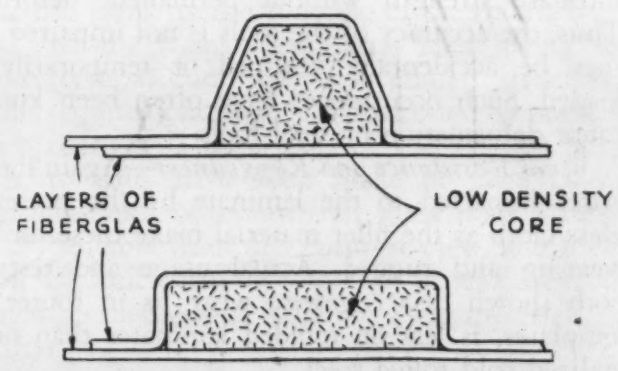
While all of the previously described aircraft tooling applications should be equally useful in similar short run operations, some of them have possibilities in other industries where higher production rates are the rule. This conclusion is based on the properties and characteristics of glass laminates in general and the following considerations in particular.

Drilling—Jigs and fixtures are used in the manufacture of a wide variety of wood, plastics and metal products. Specifications as to tooling accuracy will vary according to the material being drilled and the requirements of the product design. With present techniques, molded laminate tools should hold semi-precision tolerances in the order of 0.002 in. It is likely that methods can be developed to achieve even greater accuracy.

When tolerances of 0.005 to 0.007 in. are acceptable, the drill guide bushings are inserted directly into the tool, whereas smaller tolerances require that the bushings be mounted in small steel plates which have been previously fastened to the laminate. The attachment of these steel plates is much simplified if they are properly located on the mold in contact with either the top or bottom of the uncured laminate. During the curing process they will seat themselves and thus obviate the need of any further locating and fitting. After cure, it is only necessary to firmly attach the plates by means of rivets, bolts or cement bonding methods. Thus, the shape holding characteristics and stability of the laminate are effectively combined with the accurate machinability of steel.

Checking of formed shapes or assemblies for fidelity of contour or dimensions is often a necessary procedure in some manufacturing lines, particularly the automotive industries. The checking fixtures used for this purpose must, of course, be accurate and stable over long periods of time. Molded laminate checking fixtures satisfy both of these requirements at a much lower cost than any other known method.

Assembling—Fixtures for this purpose are used in practically every industry where a number of parts, simple or complex, must be located in proper relationship to each other for final joining or other operations



These are two of the possible methods of utilizing low density core materials in sandwich-type construction.

It is to be noted, however, that there is just as much advantage in molding small tools to assemble many intricate items as there is in making the larger tools often illustrated.

Extended Applications

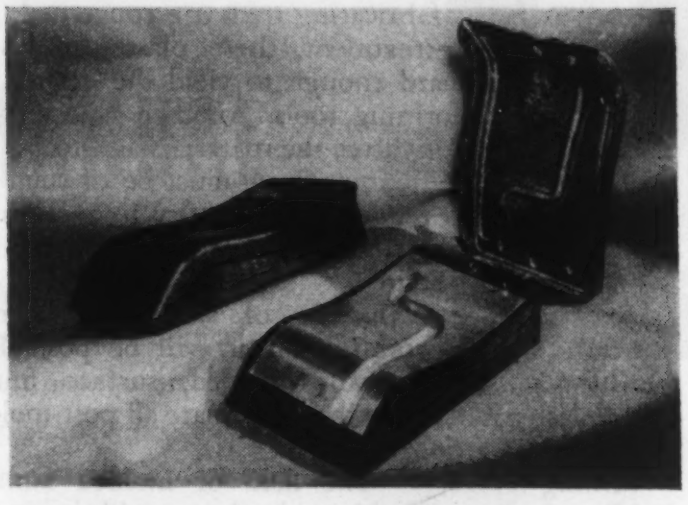
There are several types and fields of tooling which have not as yet been fully explored. In some cases experience with a moderate number of tools, so far built and used, indicate excellent utility of the application, while the outlook for others is based largely on experience with molded laminates and on the expected results of future development.

Metal Forming Tools—In this field, strength, durability, stability and good surface finish are the principal requirements. Restriction plates and some rather large press blocks have already seen limited service with good results. In addition, it is known and recognized that all types of dies for use on draw, stretch, brake and punch presses can be built. It is safe to hazard the opinion that these will find utility in any low volume operation and should satisfactorily produce at least several thousand pieces.

Notwithstanding the above, these applications are still to be placed among future possibilities. The chief reason for such an attitude is that no application is fully acclaimed prior to the accumulation of reasonably long and satisfactory service data. Secondly, some of the techniques peculiar to the economical manufacture of forming tools have not yet been proved on a large scale basis.

With respect to the special techniques which need to be employed in the manufacture of press tools, it is first of all necessary to outline the general procedure and indicate the principal differences between the molding of forming and fabricating tools. In the latter case, the laminate consists essentially of a lattice work construction. Only such portions of the contour are molded as are required for the proper functioning of the tool.

This innovation reduces material cost and eliminates all tailoring of the cloth normally necessary when a solid surface is being molded. Obviously, the strip lay-up method cannot be used to mold forming tools, since in these applications a continuous, smooth surface is a prime requirement. Moreover,



The molded laminate restriction plates shown here produce the effect of modified male and female dies.

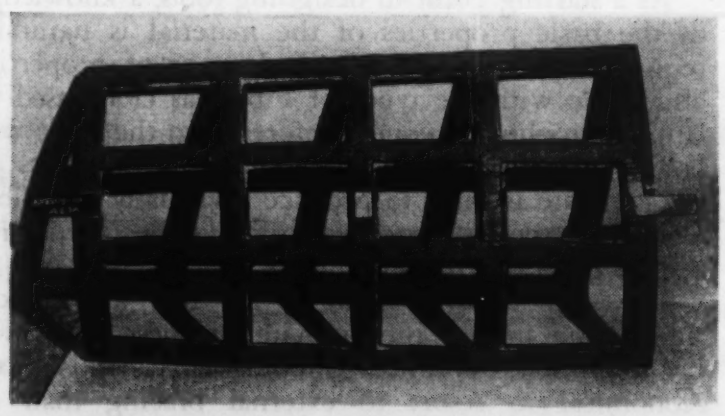
forming tools generally must have a solid backing and a flat base.

The building of such tools is essentially a two-stage process. First, a laminate shell is molded in order to pick up all details of the contour. With the cured shell remaining in the mold, a solid backing is applied which must be thoroughly bonded to the shell. The backing can be any solid, dense, rugged material, cast or molded in place. It can also be partially molded in combination with prepared flat stock.

In the last named method, additional impregnated cloth is layed into the shell in sufficient quantity to fill up all the space between the shell and a rough-cut piece of solid stock, such as commercial phenolic laminate. Under pressure and heat, the impregnated filler cloth cures and simultaneously bonds itself to both the shell and the backing block. Although the tools so produced are essentially satisfactory, indications are that more practical and economical methods will result from development and test work now under way.

It is well known that a molded surface can be only as good as the surface of the mold. The type of surfaces produced from gypsum plaster molds—used throughout this process—are presentable and satis-

The molded ribbing effect produced with low density core increases rigidity and reduces material costs.



Sandwich construction is most practical in larger tools of the type shown here.

factory as far as fabricating tools are concerned. But, without special treatment, these plaster molds are not smooth or hard enough to yield the desired surface finish on forming tools. Another aspect of the surface problem involves the materials and techniques employed in laminating. These must be of such type and nature as to reduce fiber identity to a minimum and eliminate the formation of resin pockets and areas starved of resin.

Experimental evaluation of simple, inexpensive methods shows promise that it will be possible to produce good, integrally molded, surface finishes from plaster molds and thus eliminate all post-molding finishing operations.

Milling Fixtures—The field of molded laminate holding fixtures for this and other machining operations is virtually unexplored. Nevertheless, it is evident that molding should be an excellent medium for the production of such tools since details of complex parts can be accurately reproduced because no allowance has to be made for shrinkage. A milling fixture base could be molded sufficiently thick to permit mounting on a flat base. The methods of producing such solid backing discussed under press forming tools are applicable here as well. Likewise complex shapes which can be easily molded.

Basic Tool Types—In this category are placed such tools as master models, Keller models and spotting fixtures, since they are used primarily as controls and accessories in building other tools. Generally, the same considerations apply here as in the case of forming tools. With some modification, the molded laminate tooling technique can be adapted to the production of stable, low cost models and fixtures. Such molded masters would have greater stability than the mahogany masters which are now often used in many industries.

Table 1—Typical Properties of Fiberglas Cloth Tooling Laminates

Specific gravity	1.7 - 1.8
Tensile strength, psi.	31000 - 37000
Elongation	2%
Compressive strength, psi.	11000 - 17000
Flexural strength, psi.	26000 - 33000
Flexural modulus, 10^6 psi.	1.8 - 2.2
Impact strength, ft.-lb./in. of notch	20 - 27
Coef. of thermal exp. (25 to 50 C), 10^{-5}	1.4 - 1.8
Hardness, M scale	75 - 90

As a starting point in designing tools, a knowledge of the basic properties of the material is naturally required. Table 1 shows typical range of properties obtainable with the types of Fiberglas cloth used in laminate tooling. Frequent reference to the table will not be necessary since, in practice, the thickness of the laminate is built to produce a virtually inflexible tool. Thus, the tools are generally over-designed with respect to all other requirements.

The shape and contour of the tool also affects rigidity and, in turn, the laminate thickness. Wherever the shape has but little stiffening effect, it is more economical to resort to external bracing than to increased thickness. The average tool is molded between ¼ to ⅜ in. thick except in those cases where sandwich-type construction can be utilized. This, in effect, increases the section modulus and results in built-in reinforcement.

It is apparent that with this flexible molding method it is possible to build up local areas where required. Such build-up may be desired at attaching points, bushing locations, etc.

The molded tool may be mounted—or attachments made thereto—with either conventional mechanical fasteners, such as rivets, screws and bolts, or by adhesive bonding. Expanding-type threaded inserts and studs are recommended where frequent removal of attachments are contemplated. Shoulder-type screw bushings with lock washers or press-fit bushings have been found as satisfactory as similar bushings in steel tools. If greater permanency is desired, the bushings can be bonded to the laminate with a two-stage cementing process.

The machinability of glass laminates is well known and need not be detailed here further than to note that they can be machined at faster fabrication rates than equivalent work on steel.

Plastic Tooling Prospects

In approaching this subject initially and in considering its future development, it is well to keep in mind that plastic tooling must stand on its own feet. It has a place in industry only insofar as it can serve to simplify and reduce the cost of tool manufacturing. Molded laminates will be found to qualify on both counts provided they are applied with knowledge, wisdom and imagination.

It is to be expected that new and improved methods, materials and applications will develop as soon as the process is put to work in different fields. With the impetus of such wider study and experience, added to the existing solid foundation, it can be confidently predicted that molded laminates will find a firm place in the industrial tooling picture.

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MATERIALS & METHODS MANUAL 34

This is another in a series of Manuals on engineering materials and processing methods, published at periodic intervals as special sections in Materials & Methods. Each of them is intended to be a compressed handbook on its particular subject and to be packed with useful reference data on the characteristics of certain materials or metal-forms or with essential principles, best procedures and operating data for performing specific metal-working processes.

Industrial Adhesives

by Kenneth Rose,
Engineering Editor, MATERIALS & METHODS

During the past few years there has been great development in the field of industrial adhesives—both in the adhesives themselves and in their applications. The problem of selecting the proper adhesive is just as important and just as much of an engineering function as is selection of the materials to be joined. Here, in easily assimilated form, is the basic information on adhesive types, and the general uses for which groups are intended to help determine what general class of adhesive you should use.

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Materials & Methods, February 1948
(Published since 1929 as Metals and Alloys)

Introduction

When considering the assembly of two or more parts into a unit, one of the preliminary points is whether the assembly is to be separable, semipermanent, or permanent. For a *separable* assembly, which can be easily disassembled without destruction of the parts, bolting, use of machine screws, certain new types of rivets, clamps, or clips is usually indicated. A *semipermanent* assembly is one in which disassembly is possible by destroying the bonding agent, and without any particular damage to the assembled components. Methods of forming such an assembly include riveting, soldering, staking, and sometimes adhesive bonding. *Permanent* assemblies are those in which disassembly would involve damage or destruction of the original components, and methods of accomplishing this type of assembly include welding, brazing, and usually staking and adhesive bonding.

There is some overlapping in this classification, it will be noted. Staking might be considered a semipermanent assembly method with certain types of components, but disassembly would probably result in the considerable damage of light gage metal parts. Adhesive bonding might be only semipermanent when joining materials that would withstand sufficient heat to burn away the bond, but would be permanent with many types of nonmetallics.

Adhesive bonding, then, is a method for joining parts in a semipermanent or permanent assembly. Its use dates back to the very beginnings of recorded history. Excavation of ruins of the cities of Sumeria has shown columns ornamented by attaching pieces of Mother-of-Pearl to them with natural asphaltum. The Egyptians did excellent veneer work, using adhesives to bond the wood. Animal glues have been used in joiner work for thousands of years.

Advantages of adhesive bonding that give this ancient method a place in the modern industrial world include:

1—*Applicability to practically all industrial materials.* Welding or soldering are suitable only for joining metallics or metallized surfaces; bolting or riveting are not generally suitable for use with some materials, such as glass. With our modern adhesives and techniques, adhesive bonding can be used to join almost any solids.

2—*Strength is adequate, but is usually not a deciding factor.* In relatively few applications is the actual bond strength, in either tension or shear, approached by the stresses in service. A bond strength of a few hundred psi. would be satisfactory for most purposes.

3—*Permits a wide variety of combinations in joining.* Permanent assembly of metals to nonmetals can frequently be done better by adhesive bonding than by any other means.

4—*The method fits into modern mass production assembly lines.* Automatic and semiautomatic methods of applying the adhesive and completing the bond have been worked out, and new adhesives to give quick adherence are available.

Adhesive bonding possesses certain limitations, most of them obvious. They can be listed as follows:

1—*With a few unimportant exceptions, the bond is organic, and so possesses limited heat resistance.* This immediately excludes all assemblies in which the bond must endure temperatures above about 300 F. Most of the adhesives would fail at even lower temperatures, but some of the resinous types can be used at temperatures of this order. In general, the serviceability of an adhesive at temperatures much above room temperature should be determined by test or by assurance of the manufacturer.

2—*The bond is not instantaneous.* Even with the quick-setting types of adhesives now available, it is usually best to hold the pieces being joined in juxtaposition for a given time, long or short. This is in contrast to such processes as spot welding, where the bond is formed in an interval so short that it is instantaneous for all practical purposes.

3—*Adhesion is usually specific for a given set of components, service conditions, and method of applying the adhesive.* Few industrial adhesives are general purpose materials. A change in the process, even in a seemingly trifling detail, will usually require a change in the formulation of the adhesive used.

The bond formed will be one of three types: (1) mechanical anchoring; (2) fusion adhesion; or (3) specific adhesion. The first kind of bond is formed when the surface under the coating of adhesive is porous. Surfaces of wood, leather or paper are typical. Fusion bonding takes place when the surface is soluble in the bonding agent, or in the solvent in which the bonding agent is conveyed. A partial solution of the faying surfaces then takes place, and the surfaces are fused together under pressure and subsequent evaporation. Specific adhesion is a term used to describe a kind of bonding not clearly understood. In the case of metals, for instance, a bond is formed with certain types of adhesives though there is no penetration of the surface, and no dissolving of the metal. This is called specific adhesion because it seems to be a specific property of certain types of adhesives. In the case of metal surfaces, rubber, natural or synthetic seems to be an essential ingredient in the adhesive.

Adhesives can be classified according to vehicle, or method of activation. Solvent type adhesives are those in which the bonding agent is put into solution, and the bond afterward affected by the increasing loss, and, finally, the complete removal of the solvent. Water dispersions are those in which the material, in a finely divided state, is suspended in water without solution occurring. Water can also be used as a vehicle, making up a thick mixture of the insoluble adhesive with a small quantity of it. A third type is the hot melt, for which the bonding material is fused and applied while still molten.

Another factor in the selection of an adhesive that is important to the user is its suitability to high-speed methods of application. Adhesives can be formulated to fit a given type of machine application. Many special devices for applying the adhesive to the material are available, but

they are of few basic types. These are:

Brushes. Hand-held brushes are well known and a standby in industry, but wheel brushes operating through baths of adhesive, and fountain brushes are high-production applicators.

Sprays. The spray for applying adhesive to the surface of a workpiece usually resembles the type used to spray paint. These can be adapted to use with machines also.

Rollers. Rollers of the squeegee types used for hand application, and transfer rolls are suitable for machine use.

Scrapers. Spatulas, paddles, etc., are used to apply adhesives by hand, and doctor blades on machines provide a mechanical equivalent.

Extruding devices. These range all the way from collapsible tubes to guns that lay down a ribbon of adhesive.

Newer industrial adhesives are compounded to suit a particular method of use, when that method is given as one of the requirements. Thus, if parts are to be bonded without clamping, it is usually possible to formulate an adhesive with quick tack and with sufficient wet strength to hold the pieces together until set occurs. It is not always possible to meet all conditions with a single adhesive, and there must be some compromise. For example, if considerable strength is a primary requirement of the bond, and metal parts are to be joined, a two-part adhesive of the rubber-phenolic type might be indicated. A cure under heat and pressure will give best results, so that quick tack and high wet strength could not be obtained.

Another example of the manner in which the adhesive manufacturers can formulate adhesives to meet difficult requirements is in the attaching of beer bottle labels. The adhesive desired would not be affected by cold water, so that the bottles could be placed in trays with ice water without the labels soaking off, but when the bottle is to be washed and reused at the bottling works, the label must be easily and completely removable by hot water. An albumin-dextrin adhesive was developed that possessed this unusual combination of properties.

It becomes apparent why few industrial adhesives are stock items. Each one is usually formulated to meet a set of specific conditions of use and service. They are usually mixtures of several ingredients, and frequently are mixtures of several different classes, as in the beer bottle label adhesive, where an animal glue and a vegetable glue are combined. Any discussion of adhesives must necessarily be limited to broad classifications, and to the general properties of those classifications, as there are very few standard types to be discussed.

These classifications are: (1) rubber adhesives, natural and synthetic; (2) synthetic resin types, thermosetting and thermoplastic; (3) animal or fish glues; (4) vegetable glues, carbohydrate or proteinaceous; (5) natural resins and oils; and (6) inorganic adhesives.

ADHESIVES TERMS

Adhesives have many general properties of interest to the user. From the use standpoint, some of the most important of these are:

***Tack*—the characteristic that causes one surface, coated with an adhesive, to adhere to another upon contact. It might be regarded as the essential "stickiness" of the adhesive. An adhesive having this stickiness to a high degree is spoken of as having quick tack. It is one of the most important properties in determining the suitability of an adhesive for a particular method of application. Along with tack goes *tack range*, the time during which this stickiness is maintained. Pressure-sensitive tapes possess quick tack that is, they are sticky as soon as touched and an almost unlimited tack range they do not tend to "set," but remain sticky indefinitely.**

***Wet Strength*—the bond strength that is realized immediately after the adhesive-coated surfaces are joined, and before cure occurs. This is frequently an important characteristic in industry, for an adhesive having sufficiently high wet strength may be used without clamping.**

***Ultimate Bond Strength*—the strength of the bond after cure has been completed, or substantially completed. It is not usually of paramount importance, because adhesive bonded assemblies ordinarily are not highly stressed through the bond.**

***Nonlocking Properties*—sometimes referred to as nonblocking. This is opposed to tack, and indicates the freedom of the adhesive-coated material from sticking to unwanted surfaces, as the hands of the operator, the table-top, or to the backs of other workpieces. It is important if many pieces are to be coated with adhesive and piled after slight drying, then assembled later.**

***Can Stability*—sometimes called can life, or shelf life. The length of time the adhesive can be held in storage without deterioration. *Pot life* is the length of time the adhesive remains usable after having been put into serviceable condition.**

***Specific Service Conditions*—included are such points as *color*, some adhesives being dark or black because of the materials from which they were made; *nonstaining*, of importance if adhesive or solvent might affect colored or white material with which it is in contact in the assembly; *thermal range in service*, if the assembly is to be exposed to unusually high or unusually low temperatures; *resistance to solvents*, to be considered if the bonded pieces will be subject to water, gasoline, etc., which might break the bond; *clean-up*, the ability to remove excess adhesive after the bond has been formed.**

Adhesives of Natural or Synthetic Rubber

Raw rubber is a natural adhesive. One of the first uses made of natural rubber after its introduction into Europe took advantage of these adhesive properties in combination with its imperviousness to water. The Scotch chemist, Charles Macintosh, experimenting with the sticky mass, used it as a cementing material between two layers of cloth to produce the waterproof garment that bears his name. The adhesive properties of natural untreated rubber are used today in the rubber latex adhesives, an important group to be discussed later.

Rubber adhesives are extremely versatile in both their acceptance of materials to be bonded and the form of adhesive available. They are of special importance to the user of adhesives in the metal industries because rubber seems to be an essential ingredient of adhesives for bonding to metals. While they are versatile as a class, however, no one formulation is suitable for all of the substances that can be bonded with rubber adhesives. This was brought forcefully to the attention of industry during the war, when synthetic rubbers replaced natural rubber in many applications. Attempts to use the same adhesive, usually a reclaimed rubber type, with the synthetic rubber gave such poor results that it was found necessary to ask for a new formulation suitable for bonding the new materials.

The rubber-base adhesives can be classified according to type of bond as either nonvulcanizing or vulcanizing. The vulcanizing types can be subdivided into fast curing and slow curing. With the nonvulcanizing types no cure is possible. The vulcanizing types contain curing ingredients, and possess a shorter can life. Fast curing adhesives require heat and pressure, and will bond in about 20 min. at approximately 300 F. The slow curing types are usually prepared in two parts, one of which contains the accelerator as an added ingredient, the other having sulfur added. These adhesives lose tack about 8 hr. after mixing, and cure without heat or pressure in about 10 days to 2 weeks. One part of the adhesive can be applied to one of the faying surfaces, the other part to the other surface.

The same family of adhesives can be classified according to vehicle as solvent type or water dispersions. Solvent-type adhesives are made by dissolving the rubber in an organic solvent, and the water dispersions contain finely divided rubber, natural or synthetic, in water. These latter adhesives have the nature of colloidal suspensions. Rubber latex is a natural dispersion, though the term is loosely applied to man made water dispersions of natural rubber and to dispersions of synthetic rubbers as well.

Solvent adhesives are easy to handle, easy to apply, will produce a fusion adhesion with rubbers, can be thinned to any desired consistency, and give a strong, secure bond. They possess the disadvantages of releasing inflammable vapors, and the solvent can affect certain types of materials to be bonded. This is especially true if the adhesive is to be used to seal cartons containing food.

The water dispersions can be required to conform to fire regulations in some industries. They release no noxious vapors, and so are important in the packaging of some kinds of foodstuffs. They possess immediate tack, and so are preferred by the cloth backing industry. With water dispersions, it is possible to coat the materials to be bonded with the adhesive, place them in position, then apply pressure to break the water barrier in the dispersion and get an immediate bond. Only porous materials are used with water dispersions, as the water must be absorbed or removed by evaporation after the bond is made. They are subject to destruction by freezing, and have a shorter can life than solvent adhesives.

Rubber adhesives are seldom simple solutions or dispersions of a single material. Ordinary rosin is sometimes added to give increased tackiness, and asphalt is also used as an extender and to give improved adhesion. A special type of mixed adhesive makes use of rubber and unpolymerized phenolic synthetic resin, and produces a bond of high strength and good adherence to metallic and nonmetallic surfaces. This type will be included with the synthetic resin adhesives.

Reclaimed Rubber. Reclaimed natural rubber is the most widely used type of rubber adhesive material. It has the considerable advantage of low cost, in addition to good physical properties. As old automobile tires form the largest source of rubber for reworking, adhesives are usually black. There are light-colored adhesives of this type, made from selected scrap rubber, at a slightly higher price, and these are specified when the dark color of the ordinary reclaim would be objectionable.

The solvent used is a light petroleum fraction. This is not toxic, and does not affect other materials; the adhesive can be thinned to light consistency without any difficulty, if desired.

Typical characteristics of reclaimed rubber adhesives are:

Best tack range of the rubber-base types. The material has quick tack, and good tack range, permitting time for placing and adjustment of the work.

Least critical of surface conditions. A good bond can be secured even when the faying surfaces have not been prepared with proper care. This does not mean that proper preparation of the surface is unnecessary, but that an adequate bond can be secured even if preparation has been slighted.

High wet strength. Clamping is not usually necessary when using this type of adhesive.

Good aging properties.

Long can life. Unless the solvent evaporates, the adhesive seems to last indefinitely on the shelf. If evaporation has occurred, addition of light gasoline will restore the material to serviceable condition.

Moisture resistance is good.

It is not susceptible to attack by fungi.

Bond is maintained through a temperature range of about −30 to 160 F.

Reclaims are available in both water dispersions and solvent adhesives. The water dispersions are somewhat lighter in color than the solvent types, and have the same quick tack.

These are adhesives suitable for use with a wide range of materials, and have an advantage costwise over the other rubber-base cements. They might be called the general-purpose members of the group. Materials with which the reclaimed rubber adhesives can be used include metals, natural rubber, fabrics of cotton, wool, or silk, leather, glass and paper.

Natural Rubber Latex. This is the uncoagulated sap of the rubber-producing plants. It is a natural dispersion of rubber in, essentially, water. As described in connection with water dispersions, it is a milky liquid, subject to destruction by freezing or evaporation, and will coagulate gradually upon standing. Because of its light color it is a preferred adhesive in the large cloth backing industry. The natural latex is frequently compounded with water dispersions of other rubber-base adhesives,

Adhesive bonding replaces riveting formerly used in joining the brass reeds and plastic cases in the making of harmonicas. (Courtesy: Minnesota Mining & Manufacturing Co.)

and reclaimed rubber, especially the lighter-colored types, is much used for this purpose. Compounding of paper and leather also takes much of the total production of latex or compounded latex.

Like the reclaimed rubber types, bonds affected with natural rubber are attacked by naphtha and other petroleum-derived solvents. Rubber, both natural and reclaimed, is also subject to deterioration upon prolonged exposure to sunlight.

Cyclized Rubber. When rubber is treated with chemicals, principally sulfuric acid, it can be made tougher, and loses its ability to be vulcanized with sulfur. Chemically, the straight-chain rubber molecule becomes a cyclic compound. Forming a tougher, harder bond than the untreated rubbers, adhesives of cyclized rubber have been used for bonding rubber, paper, and metals. Its use has been reduced with the growing production of nitrile synthetic rubber adhesives. These treated rubbers formed the first of the rubber-to-metal adhesives.

Chlorinated Rubber. Another chemically treated rubber that provides a tougher material for the bonding agent in adhesives using it as a base. They have been supplanted to some extent by newer rubber-base compositions, but are still used, as are the cyclized rubber adhesives for bonding rubber, metals, and paper.

One of the properties conferred upon the rubber by this chemical treatment is improved chemical resistance, including resistance to petroleum products. It finds use in the coating field, where the resistance to chemical attack is of value.

Chloroprene. As a base for adhesives, chloroprene synthetic rubber has a definite field. It is, first of all, the adhesive giving the best bond with neoprene synthetic rubbers. It possesses good tack, though not as good as the reclaimed natural rubbers. Its cost is also higher than that of the reclaim adhesives. Solvent types are made with aromatic hydrocarbon solvents, benzene or toluene, and vapors are more toxic than those of naphtha.

When a bond is to be made between neoprene or acrylonitrile synthetic rubbers, or when the bond is required to have properties given by the neoprene-base adhesives only or to a greater measure than with reclaim types, use of neoprene adhesives is indicated. The special properties of the neoprene adhesives are:

High solvent resistance. Neoprene adhesives have good resistance to petroleum products.

Good heat resistance. Service temperatures of about 50 to 75 F higher than those for natural rubber adhesives may be suitable, depending upon the formulation of the neoprene material.

Good aging characteristics in exposure to sunlight. Deterioration in exposure to sunlight has been a weak point with the natural rubbers, and this synthetic offers an improvement.

Generally higher bond strength. This is dependent upon formulation of the adhesives, but neoprene types are generally stronger.

Good resistance to acids and alkalies. These adhesives can be used cold, or, if a stronger bond is required, curing at about 300 F for 20 min. under pressure (heat-vulcanizing) can be used. When elevated temperatures cannot be used, but the advantages of the cured material are desired, use of an accelerator and longtime cure at room temperature (about 7 days required) will give the same results.

Neoprene rubber adhesives are being used in the bonding of synthetic rubbers, metal, fabrics, leather, and composition tile.

Acrylonitrile Copolymers. Synthetic rubbers of the type formerly referred to as Buna N or GR-A rubbers likewise have a place in the manufacture of rubber-base adhesives. The reclaimed rubber adhesives, the neoprene adhesives, and the acrylonitrile adhesives, arranged as a series, would show a decreasing tack, increasing strength, and increasing chemical and solvent resistance. A feature of this increasing solvent resistance is that the solvent required to produce adhesives of the solution type must be a ketone or an ester, of such properties that it will frequently attack paint or other preparations on or near the surfaces to be bonded.

As has been stated, the acrylonitrile-base synthetic rubber adhesives are less tacky than either the reclaimed rubber types or the neoprenes. They can be used to make some of the few adhesives that are nonblocking. The faying surfaces of the pieces to be joined can be coated with the adhesive, allowed to stand for about 2 min., then stacked and stored until ready for the actual bonding operation. Reactivating the adhesive with a spray of the thinner is all the preparation that is needed for bonding. The stacked pieces will not lock, or block, during storage. Only sufficient pressure to insure contact is needed to effect the bond.

Along with low tack, high strength, and good chemical resistance go excellent aging properties. Bonds made with adhesives based upon these synthetics improve with age for several weeks or longer. The adhesives are light in color, and so are nonstaining unless the solvent attacks colors or materials being bonded.

Acrylonitrile synthetic rubber adhesives are especially suited to bonding synthetic rubber, especially of the same composition. They can be used for about the same materials as the other rubber-base adhesives, but, because of higher cost and slightly more difficult handling, are chosen when some one of their desirable properties, as given above, is needed.

Styrene Copolymers. These synthetic rubbers are usually referred to as GR-S rubbers, and correspond in general to the compositions called Buna S by the Germans. The designation Buna S is sometimes used to indicate this broad class of synthetics, though the industry is trying to encourage the newer American terminology to designate these American-made synthetic rubbers.

Adhesives made from GR-S synthetics closely resemble the natural rubber reclaims, but have better aging properties. Tack is somewhat poorer. In addition to the solvent-type adhesives, water dispersions of the material are much used. The water dispersions are favored in the cloth backing industry because of the light color and nonstaining qualities of the adhesive. The solvent types use the same solvents as natural rubber.

The temperature range through which the adhesive remains effective in service is the same as for natural rubber — about -30 to 150 F. This is one of the adhesives used in the manufacture of pressure-sensitive tape, for which an extremely wide tack range is a requirement. It is used in the combining industry to laminate metal foil to paper, and to make various combinations of leather, fabric and paper in addition to the backing or combining of cloth already mentioned. It is also suitable for joining rubber, plastics and glass, and in general has the same adaptability as the natural rubber adhesives. When plywoods or veneers are to be made up in panels for a particular article, as radio cabinets, adhesives of this type are sometimes selected.

Polysulfides. Adhesives made from the polysulfide synthetic rubbers, of which Thiokol is typical, are not widely used, but serve several highly specialized fields. They have the highest chemical resistance of the entire group, but are also rather expensive. They possess an unpleasant odor, and so are unsuitable for many types of service, such as those in which they would be placed near foodstuffs. The fields into which they have gone most successfully are those requiring high solvent resistance, such as the cementing of lacquer hose lines or the sealing of cans of organic liquids.

When impervious surfaces, which permit no solvent evaporation from the broad areas to be bonded, are to be joined with the polysulfide-base adhesive, the bonding agent can be made up with an accelerator instead of a solvent. It is then used as a viscous liquid that solidifies by action of the accelerator instead of by removal of the solvent. The polysulfide rubber in the adhesive as applied is unpolymerized or incompletely polymerized, and the solid resin is formed when polymerization takes place. This is called the low-temperature polymerizing type.

There are polysulfide-base adhesives in which both solvent and accelerator are used, the solvent being used as a thinner, and the accelerator to complete the polymerizing reaction.

Butyls. Adhesives made from that group of synthetic rubbers called the butyls have much the same properties as those from reclaimed rubber. They have much better aging properties, and form a better barrier to air or vapors, a property taken advantage of when the material is used for can sealing. They are also very light in color.

Solvent adhesives use the same liquids as natural rubber to effect solution—the lighter fractions of petroleum. The butyl-base adhesives will bond the same types of materials as the other rubber-base cements.

Solvents. Solvent adhesives have been mentioned in connection with the various types discussed. The solvents themselves are frequently important as limiting factors, as has been mentioned in connection with odor or staining characteristics of the adhesives. The usual solvents for rubber adhesives are:

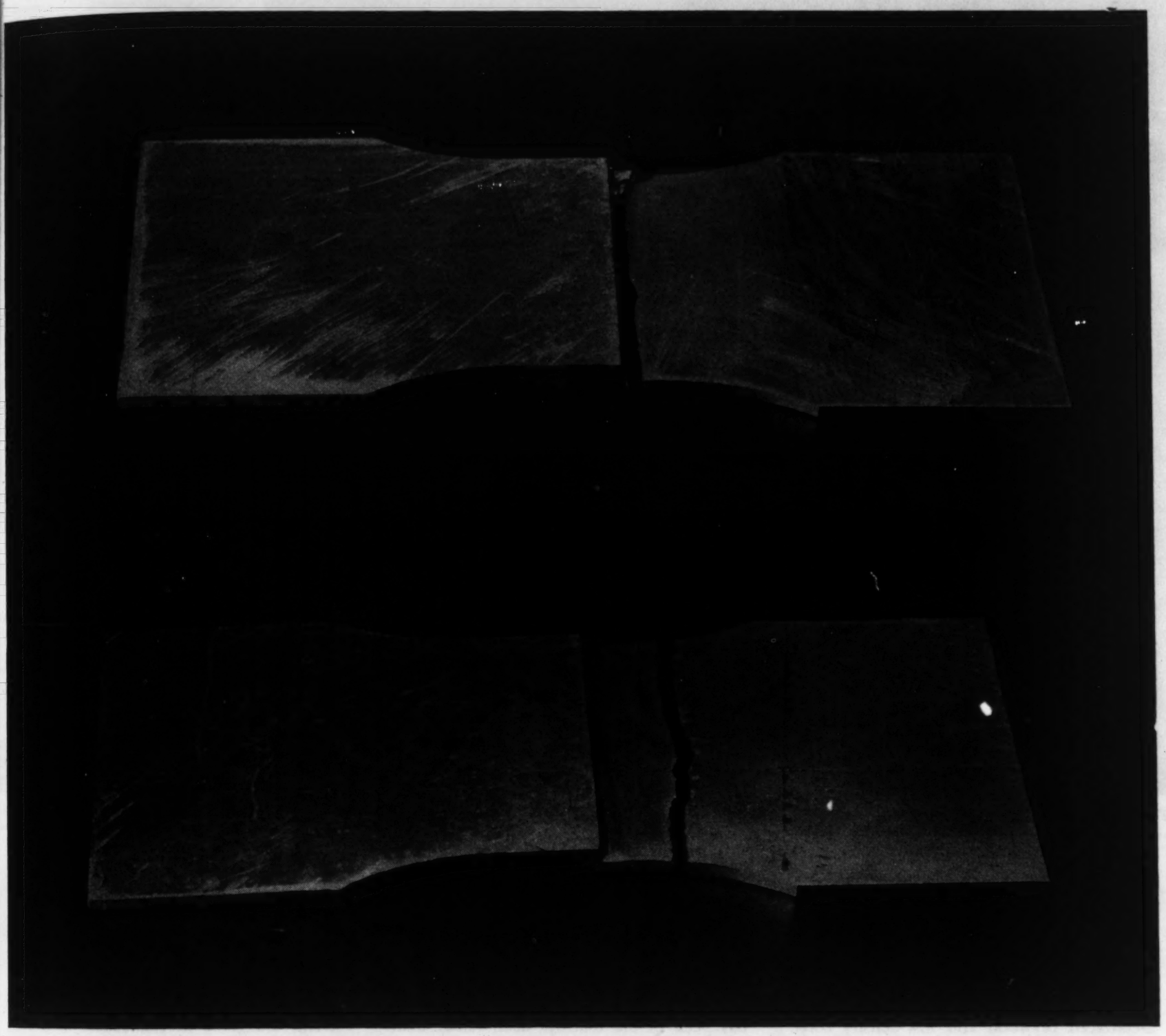
Natural or reclaimed rubber
Chloroprenes
Acrylonitrile copolymers
Styrene copolymers
Polysulfides
Butyls
Cyclized rubber
Chlorinated rubber
Naphtha or gasoline
Toluene; ethyl, methyl, or isopropyl acetate; benzene
Methyl-ethyl ketone, or other ketones
Naphtha, gasoline, benzine
Ethylene dichloride or a few other chlorinated solvents
Naphtha or gasoline
Benzene
Methyl isopropyl acetate or toluene

Blended or Compounded Adhesives. The use of asphalt and rosin as blending or extending ingredients has already been mentioned. When an adhesive is required to be harder, or to have higher-temperature resistance, chlorinating of the rubber, either natural or synthetic, is sometimes done. The resulting adhesive lacks elasticity, and so is not used for bonding elastic materials. Chlorinated rubber adhesives have been listed and described in brief.

Another group of compounded adhesives must be mentioned here. They are rubber-base adhesives hardened and strengthened by adding synthetic resins, usually phenolics, to the composition. The group of adhesives containing about equal parts of thermosetting resin and rubber, natural or synthetic, developed just before and during the war primarily for metal-to-metal bonding, will be considered with the resinous adhesives. There is another group of these adhesives, with the composition mostly rubber, but containing about 10% of resin, frequently a phenolic, to obtain greater strength. The resin is polymerized in the cure of the adhesive.

How Rubber Adhesives Compare

	Reclaims	Chloroprenes	Nitriles
Upper Service Temperature Limit	About 150 F	About 200 F	About 250 F
Tack	Excellent	Less tacky	Least tacky
Strength	Good	Better	Best
Chemical Resistance	"	"	"



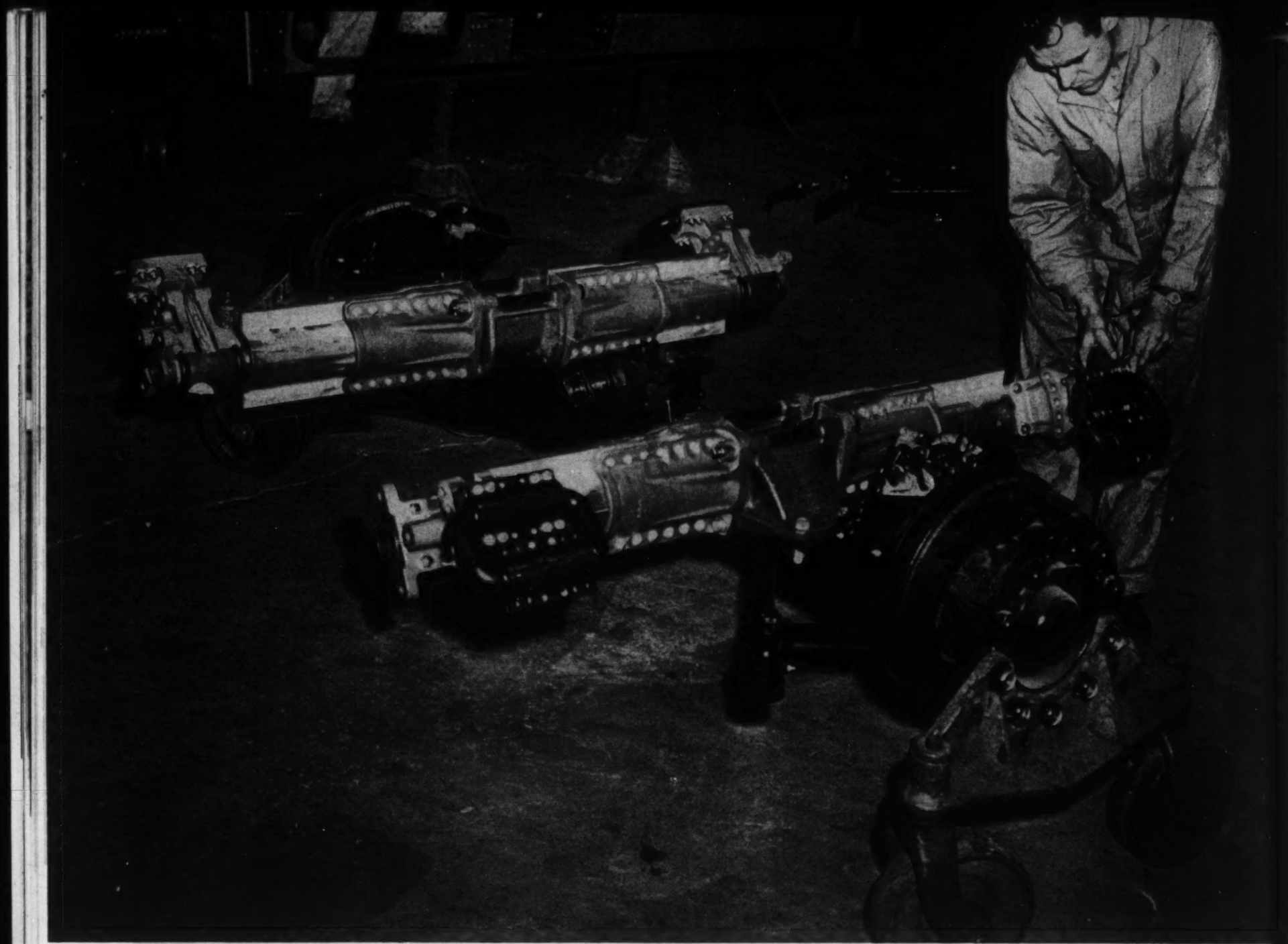
Resin-rubber type adhesives withstand bending stresses as shown with this duralumin test piece. The piece broke, but the joint is still intact. (Courtesy: Resinous Products & Chemical Co.)

Synthetic Resin Adhesives

Shortly after celluloid, the first of the modern synthetic materials referred to as plastics, was produced, it was found that it could be dissolved in such solvents as acetone, and the wetted celluloid could be made to adhere to itself. The viscous solutions of cellulose nitrate that were developed from this idea became one of the first waterproof adhesives, and later formed the basis for airplane "dopes" with which the cloth covering the wooden framework of early aircraft was made waterproof. It is now a useful industrial and household adhesive for a wide variety of materials.

With the development of the first phenol-formaldehyde resins 40 years ago, the groundwork was laid for a new type of adhesive. Using the unpolymerized materials for the resin as a mixture placed at the glueline, and then completing the reaction by applying pressure and heat, gave a highly water-resistant bond by the formation, in place of the Bakelite-type resin. Bonding with this adhesive meant clamping until the resin had been cured, for the materials as placed had no tack whatever. However, it held out the possibility of using plywood out-of-doors without the necessity of careful sealing off of the glue, for the bond was now the most water-resistant part of the whole.

From these thermosetting resin adhesives and the rubber types came a new class of bonding agents combining the strength of the resins with the versatility of the rubbers. These adhesives and their successors



The ability to bond rubber to metal makes possible the production of rubber springs such as these for use on inter-city busses. (Courtesy: B. F. Goodrich Co.)

have made possible some of the most useful of the composite materials, such as metalfaced plywood and low-density cored materials.

The thermoplastic resins make excellent adhesives for bonding plastics of the same composition. Their largest use otherwise has been in the coatings field, rather than as adhesives. While all of the thermoplastics are capable of fusion bonding under the effects of a solvent and pressure, all are not used as commercial adhesives. Suitable solvents are given in connection with the types to permit selfbonding of these materials.

Thermoplastic Resin Adhesives

Cellulosics

Cellulose Nitrate. This is the first of the thermoplastic adhesives in point of time and of general adaptability. It is one of the most used adhesives for bonding thermoplastic resins, and is a standard item in the shoe manufacturing industry. Adhesion to paper, textiles, wood, rubber, glass, and ceramics is good also.

The high flammability of cellulose nitrate is a factor mitigating against it, but this has not barred its use in those fields where it fills a need. It forms a good barrier against moisture, and holds up well in outdoor use.

Adhesives using this as a base material are made with ketones or esters as solvents. Fusion welding, and similar processes in which the solid plastic is heated to its flow point and a bond formed by pressing the parts together, is also used.

Cellulose Acetate Butyrate. Solvent adhesives using the same types of solvents as cellulose nitrate are made from the acetate butyrate also. It has the same versatility of application, but is mostly used for bonding thermoplastic molded parts and other pieces. The material remains flexible in the bond, and combines good toughness with good solvent resistance. It can be used out-of-doors, but its resistance to the weather is not as good as that of the nitrate.

Cellulose Acetate. With rather poorer adhesion to many surfaces than cellulose nitrate, the acetate possesses better heat resistance, and is frequently used in combination with the nitrate. It is most familiar as the adhesive for photographic film, which is usually a cellulose acetate material. It is definitely inferior to the nitrate in resistance to weather, but has better solvent resistance.

Ethyl Cellulose. Use of ethyl cellulose as an adhesive is practically confined to bonding parts of the same material, but it possesses characteristics that would seem to indicate a wider field for it when it becomes

better known. It has good resistance to deterioration at either elevated or low temperatures, and is flexible and tough. Resistance to alkalies is better than that of most thermoplastics. While the material is not as versatile as the nitrate in its bondability, it forms satisfactory bonds with thermoplastics, leather, paper, textiles and rubber.

Vinyls

Polyvinyl Acetate. The most versatile of the vinyl adhesives is the acetate. Like several other of the vinyl resins, polyvinyl acetate is sufficiently elastic or "rubbery" to permit bonding to metals. In addition to solvent adhesives and fusion or hot melt types, the acetate forms excellent water dispersion adhesives.

Vinyl adhesives, especially the emulsion types, are free from taste or odor, and possess good bonding qualities for nonporous films such as cellophane. This makes them important in the packaging of food. Cellophane and plastic film containers, and wet-strength bags for wet vegetables or frozen foods, use large quantities of vinyl or vinyl-blended adhesives. Solvent types are favored for making the container, and the water dispersions for sealing the container after filling with food.

Vinyl adhesives in general have quick tack, and are favored for high-speed operations such as the machine forming of cellophane bags. They are compatible with many other types of resinous adhesives, particularly cellulose nitrate and acetate. They may also be toughened by the addition of phenolic resins, as is the case with the rubber-base adhesives.

Thermoplastic and thermosetting resins, leather, paper, textiles, wood, metals, ceramics and rubber form good bonds with polyvinyl acetate adhesives.

Polyvinyl butyral. Polyvinyl butyral has replaced cellulose nitrate as the nonshattering interlayer in saftey glass. Although its use for this purpose has overshadowed its adaptability, it possesses excellent properties as an adhesive, particularly its bondability to a wide variety of substances. Polyvinyl butyral adheres well to metals, glass, both thermosetting and thermoplastic resins, leather, paper, textiles, rubber, ceramics, and wood.

Other aldehyde derivatives of the vinyls as well as the butyral are used in adhesives, though all possess about the same general properties. They afford fairly good moisture resistance, and resist the effects of heat and cold well.

Vinyl Chloride-Acetate Copolymers. When increased water resistance, or better resistance to chemicals, organic solvents, or deterioration at elevated or low temperatures is desired in vinyl acetate adhesives, copolymerizing with the harder vinyl chloride can produce a material with the required properties. The adhesives made from these copolymers possess properties ranging between those of the hard, tough, and moisture-resistant chloride and the flexible, less resistant acetate, depending upon the proportions of each in the copolymer. Adherence to most surfaces is less firm than that of the acetate, but by additional changes of composition the bonding qualities can be improved. The range of materials bondable with these adhesives is about the same as for the other vinyls.

Polyvinyl Alcohol. The polymerized vinyl alcohol is slightly water soluble, and so makes a poor barrier to moisture. It finds use in the packaging of food when a waterproof seal is not required, however. It bonds especially well to paper, textiles and leather, and leaves no taste nor odor. Water dispersions of the alcohol with the acetate are also used as adhesives.

Vinylidene Chloride-Vinyl Chloride Copolymers. When good resistance to solvents and to deterioration at low temperatures is required in an adhesive, a copolymer of vinylidene and vinyl chlorides may be useful. They are tough and strong, and possess good water resistance. The copolymer has been used particularly with paper and textiles.

Acrylics

Methyl Methacrylate. The greatest use of solutions of methyl methacrylate polymer as an adhesive is for self-bonding. It is used in solvent form generally, though hot melt bonding is done at times. Because the films are brittle, methyl methacrylate adhesives are not used alone for bonding flexible parts. Good adherence to thermoplastic resins, leather, textiles, paper and ceramics is reported.

Ethyl Acrylate. Flexibility in methyl methacrylate adhesives can be obtained by copolymerizing with ethyl acrylate. Because of this flexibility, and its permanent tackiness, it is much used as an ingredient in adhesives for pressure-sensitive tapes. It flows at moderate heat, and bonds especially well to paper.

Styrenes

Polystyrenes. Polymers of styrene are seldom used alone as adhesives. The excellent electrical properties of the styrenes make it a valuable element in friction tape for electrical use. It is copolymerized with other substances having adhesive properties for such applications. It possesses excellent water resistance, and bonds well to paper and textiles, thermoplastic resins and rubber.

Another group of thermoplastic resins, the alkyds, are important in the coating field, and are finding some application as ingredients in adhesives. They are tough, bond well to a wide variety of substances, and have good water and solvent resistance, but possess limited heat resistance.

Thermosetting Resin Adhesives

Phenol-Formaldehyde. The basis for the production of really waterproof plywood was the use of unpolymerized phenol-formaldehyde as the glue-line element between wood plies, and its cure in place under heat and pressure. This was a rather difficult task with large sheets of thick material, as temperatures of about 300 F at pressures of about 500 psi. were required. Conduction of heat through the wood was slow, and it was required to hold the pressure for several hours after cure was completed to permit the bonded wood to cool. Use of dielectric heating, in which the heat is generated at the glue-line instead of being brought there by conduction from the press platens, has greatly increased the production rate, and the adaptability of the wood laminating technique.

The phenol-formaldehyde mixture is supplied as a powder, to be mixed with water as a vehicle and applied; as a film, to be placed between the objects being bonded; and as liquids. In each case the material is unpolymerized or incompletely polymerized, and the bond is formed by completing the polymerization.

Several general properties apply to the thermosetting resin adhesives in general, and may be given here:

1—*Shelf life is limited.* Depending upon the formulation of the adhesive, shelf life may be a few weeks or many months. Cold-setting resinous adhesives use a catalyst as an ingredient in the powder, and polymerization is then completed by addition of water. The powder is supplied in sealed cans, and will keep quite well as long as the temperature of the storage place is not allowed to rise above ordinary room temperatures, and even traces of moisture are not allowed to reach the contents of the can. In other forms shelf life is usually shorter.

2—*Field of applicability is limited.* For those adhesives curing by heat and pressure, the conditions of cure automatically fix limitations. Wood, rubber, thermosetting resins, and ceramics are the substances for which these resins have been most successful as bonding agents.

3—*They possess no initial tack.* All work must be clamped in position, and held until cure has been at least partially completed. This considerably restricts use of thermosetting resinous adhesives.

4—*Cost is usually moderate.* The phenol-formaldehyde adhesives are low-cost materials, but the resorcinol types are much

more expensive, costing about 70¢ a lb.

5—*A high-strength bond is produced.* The cold polymerizing types, in which a catalyst is used to speed the reaction at room temperature, develop lower ultimate bond strengths, but both types produce a bond satisfactory for general use.

6—*The bond is thoroughly waterproof.* In contrast to the moisture-resistant types of adhesives, these cements are not resoluble even upon longtime immersion in water. Plywood properly bonded with the thermosetting resinous adhesives is suitable for outdoor use.

7—*The adhesive is resistant to attack by fungi.* Earlier wood glues were of animal origin, and when slightly moist, as in a damp tropical atmosphere, they were highly susceptible to attack. Both phenol and formaldehyde are powerful antiseptics, and the resulting polymer is immune to attack.

Resorcinol-Formaldehyde. Adhesives formulated over the resorcinol-formaldehyde polymerization will cure at room temperature without undue use of a chemical catalyst. Better bonding results if the cure is made at a temperature of about 180 F, when the reaction is completed within a few minutes.

The range of substances bondable is slightly wider than for the phenol-formaldehyde compositions. Thermosetting resins, natural and synthetic rubbers, some thermoplastic resins, and properly treated metal surfaces can be joined in addition to wood.

A convenient formulation for a cold setting resinous adhesive for which an acid catalyst is not required consists of a mixture of resorcinol- and phenol-formaldehyde ingredients for copolymerization. This reduces the cost of the adhesive while obtaining practically the advantages of the resorcin type.

Urea-Formaldehyde. Plywood that will not be subjected to exposure to weather may be effectively bonded with urea-formaldehyde compositions. Both elevated-temperature and room-temperature curing can be accomplished, if the proper formulation is selected. The adhesive is nonstaining, and so is chosen for decorative panels, for textiles, and for paper. Its moisture resistance is limited, however, and it is not recommended for exterior use.

Copolymerization with other thermosets, and inclusion of inhibitors, improve the moisture resistance of these adhesives.

Melamine-Formaldehyde. Another nonstaining thermosetting adhesive is the melamine-formaldehyde composition. These are available only as heat-polymerizing types, and have a limited use as adhesives. Their water resistance is better than that of the urea-formaldehydes, and their white color makes them acceptable as bonding agents for wood veneers, paper, and textiles.

Resin-Rubber Adhesives

Immediately before the war, in 1938 and 1939, preliminary announcements were made of a metal-bonding adhesive that contained approximately equal amounts of thermosetting resin, usually a phenolic, and rubber, at first natural rubber. These adhesives possessed high strength, of the order of 5000 psi., and could be cured by heat and pressure to form a firm bond that retained a slight elasticity, and would adhere tightly to metals, rubber, plastics, wood, leather, ceramics, glass, and textiles. No general release of information as to composition was made, but the adhesives, offered as Cycleweld, Pliobond Reanite, Bostick, etc., all followed the same general formula. The thermosetting resin was varied, and the rubbery constituent became one of the synthetic rubbers when natural rubber disappeared from the market during the war; for low-temperature, low-pressure curing an accelerator might be added.

These adhesives were developments of earlier formulations that had added a small percentage of thermosetting resin to various rubber adhesives to harden them, and to obtain greater strength. The cure of the resin is effected in the intimate mixture, contributing strength and hardness, while the rubbery element gives adherence to a wide variety of materials, and flexibility.

While a series of compositions is offered by each of the manufacturers, only the general type composition can be given here, as detailed information has not yet been released.

The most recent development in this field has been the substitution of one or more of the vinyls for rubber as the elastomeric element in the adhesive. Good bonding to metal seems to be possible with these adhesives, and they seem to retain much of the versatility of the rubber-resin types.

Glues of Animal, Fish and Vegetable Origin

Probably the oldest manufactured glues are those of animal origin. The age of some of the glue wooden pieces removed from Egyptian tombs has been estimated at more than 3000 years, but examination indicated that the glue bonds were in good condition. This attests to the durability of animal glues when the glued pieces are kept in a dry atmosphere at room temperature. In a warm, moist atmosphere the glue tends to deteriorate rapidly, due to its taking up of moisture from the air, and subsequent bacterial or fungal attack.

A general characteristic of the animal glues is their solubility in water, which brings about their use as water solutions, and also implies a limited water resistance. All are proteinaceous in character. They are all easy to apply, and so have been favored by some industries not highly mechanized, such as the early woodworking industry.

Principal types are:

Casein glues. Derived from milk protein.

Soluble dried blood. A slaughterhouse byproduct.

Blood albumin. Also a slaughterhouse byproduct.

Hide glue. Probably the oldest, and still the favorite in the furniture industry. A product of the modern abbatoir.

Bone glue. Another early type, now produced in quantity from the meat industry's offal.

Fish glue. Refuse from the fisheries forms the source for this type, also hundreds of years old.

Of these types, it can be said in general that casein glue is a slightly water-resistant wood glue, the blood products are specialties, hide glue is a wood glue, bone glue is used primarily for paper, and fish glue is a cold glue for wood.

Casein. Casein glues are supplied to industry as dry powders to be mixed with water when its use is intended. They set up rather rapidly after water is added, and provide a strong bond with wood, textiles and paper. Use of formaldehyde in the adhesive composition precipitates the casein as an insoluble substance, providing the rapid set upon addition of water, and giving a measure of moisture resistance to the bond. The material is still subject to bacterial or fungal attack. They are offered as household adhesives because of the ease with which they may be used.

Soluble Dried Blood. This is the blood

of animals, with fibrin and water removed. It is sold as a powder, almost black in color, and is used to give a degree of water resistance to soybean flour adhesive in the manufacture of plywood. It is low in price, and provides a hard film that bonds well to paper, wood, leather, and textiles. Quick set and slightly improved water resistance can be obtained by applying heat, at about 150 F.

Blood Albumin. This is a refined product obtained from animal blood, and consists of the dried blood serum. It is sold as a light-colored powder for specialty adhesives and other purposes. It has good adhesive properties for paper, textiles, leather, and, particularly when hot set, for metals also. Because it is acceptable for use as an adhesive with food products, it finds application in food packaging. The cork liners for beer bottle caps, for instance, are attached with an adhesive of mixed blood albumin and egg albumin, which gives almost instant bonding between the cork and the metal. Use of heat, at about 150 F, gives quick set and slightly improved water resistance.

Although rather expensive, blood albumin has properties that give it a field in spite of all the new synthetics. One of its big applications is in leather dressing, for which it provides a coating that gives a good surface, some water resistance, and still permits water vapor to pass.

Hide Glue. Hide glues are still the favorites with the furniture industry, and with many other woodworking industries. They are strong, have long shelf life, good pot life, good tack, and fairly quick set. Glues are available in a range of "tests," and it is important that the proper test be selected for the conditions under which the glue is to be applied. Animal glues "jell" at about 100 F, and this permits rapid tack in bonding. If the surfaces being joined are above 100 F, the low-test glues will not set quickly, while high-test glues will set in a few moments. If the test is too high, the glue may set before the pieces can be joined.

Abrasive wheels and abrasive sticks are bonded with animal glues when water resistance is not a condition of service. A secure bond is also obtained with leather, paper, or textiles.

Bone Glue. Bone glue is a typical paper glue. It is estimated that about 55% of the production goes into gummed paper tape. It possesses adequate strength, is cold-water soluble, and can be activated by cold water and bonded within 4 sec. Sealing of shipping containers and use as a binder in wall calcimine account for large quantities also. In addition, it is used as a constituent of combined adhesives to give a higher test.

Fish Glue. Made from dried fish offal, these are familiar cold glues for woodworking and for household use. They possess ease of application as an advantage over the high glues, which are usually used as a warm viscous solution.

Adhesives based upon the vinyl resins are used to fabricate paper milk containers. In this application the absence of taste and odor, plus waterproofness, are primary requirements. (Courtesy: Bakelite Corp.)

Vegetable Glues, Carbohydrate or Proteinaceous

Vegetable glues, also dating far back in history, are based upon starch and vegetable flours. They are widely used today in industry as paper and labeling adhesives, for forming paperboard articles, and in woodworking. It is rather difficult to set up clearly defined classifications, as these adhesives, to perhaps a greater extent than most other types, are used in complex formulations. The principal elements are given here, so that their effect in an adhesive may be understood even though there may be no adhesive to correspond to the single ingredient.

Starch, Plain and Modified. Starch from corn, potato, sago, or wheat, and tapioca starch are used in industry, usually in modified form. By giving it an acid treatment and achieving a partial hydrolysis, the starch can be given greater fluidity. Continuing the acid treatment with heat, a form of dextrin results, called *British gum.* Further treatment with heat and acid produces the adhesive material called *dextrin.* Quick tack and increased solubility are obtained by this process, increasing as the treatment of the starch progresses. Other chemical treatments of starch produce the *chlorinated starches, starch acetate, allyl starch,* etc., used as ingredients in adhesives, sizes, or coatings.

Adhesives based upon starch are weak and have poor water resistance, but bond quickly to paper and textiles. They are labeling adhesives especially, and find wide use in the textile industry as coating materials for fine cottons during weaving. They adhere well to glass in applying labels, and are much used in packaging. They have quick tack, good shelf life and pot life, and are easily adapted to use in automatic machinery. They are white, nonstaining, and fast setting. They are also used for attaching wallpaper, on postage stamps and envelopes, sizing paper, etc.

Vegetable adhesives of a proteinaceous nature include *soybean flour,* which is derived from soybeans as its name indicates, and *zein,* derived from maize. Soybean flour has already been referred to as an adhesive for plywood, and it has other applications with paper and textiles. Zein produces a hard, water-resistant film, especially when deposited from alcoholic solution.

Natural Resins and Oils

Resins and oils, both mineral and vegetable, are used in adhesives both by themselves and in combination. *Rosin* and its derivatives are used in hot melt, solvent, and water dispersion form, as well as in

combination with other adhesives. As a hot melt adhesive it is much used in can labeling, where it functions as a hot pickup gum in automatic machines. *Shellac,* a familiar vegetable resin, can be used in alcoholic solution or as a hot melt. It fuses at about 300 F, and produces a clear film with good water and oil resistance. It adheres well to wood, metals, paper, textiles, and plastics. Alone, it is more used as a coating to form a water barrier than as an adhesive, but it finds application as a modifier in formulating adhesives to develop high tack.

Asphalt, a mineral material, is used as a hot melt or as a solvent-type adhesive. It forms a binder and a water barrier in building paper; serves as a blender and extender for various other adhesives, notably the rubber-base adhesives; and acts as a binder in certain of the materials referred to as cold-molded plastics. It possesses good water resistance, and resists deterioration at low temperatures, but softens appreciably at moderately elevated temperatures. It possesses permanent tack at ordinary temperatures. Paper, rubber, textiles, leather and plastics are bonded by this natural adhesive, as well as many nonporous substances such as metals, stone, glass, etc.

Inorganic Adhesives

Several inorganic materials serve as adhesives in limited applications and for special purposes. *Sodium silicate,* or water glass, becomes a waterproof adhesive for boxboards and cartons, and for labeling shipping containers. Because it is strongly caustic, it will frequently stain the dyes on colored materials, and must be used with caution. It is used for bonding corrugated paper.

Litharge-glycerin forms an adhesive with limited use in industry, but helpful when a bond must withstand high temperatures. It is used in ceramics applications.

Magnesium oxychloride is another binder and filler used in ceramics. Both of these formulations are mixed as needed, and used at once.

The Place of Adhesive Bonding in Industry

Successful use of the adhesives described here depends upon a proper selection of the bonding material for the operation, and a proper design of the parts to obtain maximum benefits from adhesive bonding as an assembly method. For the first, there is no substitute for the advice of the adhesives manufacturer. As has been pointed out, production of adhesives is not a business in which types have been standardized. Adhesives are usually tailormade for a specific application. The conditions that will influence the formulating of the adhesive have been suggested, and all of these should be stated in detail when asking the adhesives manufacturer to recommend a formulation.

The second point may mean substantial savings to the user of adhesives. Adhesives join materials over a broad area, instead of localizing stresses at one or more points, as with spot welding or mechanical fastening. It is frequently possible to simplify construction by eliminating bracing, stiffeners, local reinforcements, or framing. In addition, labor may frequently be saved by this type of assembly.

Adhesive bonding is no longer a cheap, rather shoddy substitute for a better method of assembly. It is a reliable, efficient assembly method with its own advantages and limitations, and should be considered by the methods engineer as one of the possible procedures when those advantages are offered, and when the limitations do not bar it for the particular project being studied. Adhesive bonding must be considered as an assembly method just as are welding, soldering, riveting, bolting, etc., with its own place in modern technology.

Several examples point up this view. When the automobile industry first began its swing from the wooden body to the all-metal body, it was the practice to use nailing strips along the steel parts to permit tacking the upholstery in place. There was no way of welding the nonmetallic parts into place, as the steel was welded together, so this laborious and time-consuming method was used to fasten the nonmetallic components to the steel. When the proper adhesives were developed and offered to the automobile industry, it was possible to eliminate the use of nailing strips altogether, and to attach the upholstery, now sponge rubber, directly to the steel by adhesive bonding. Adhesive bonding was the assembly method that bridged the gap between the metallics and the nonmetallics. Needless to say, costs were considerably reduced. At the same time, construction was made simpler and more durable.

It is only within the last decade that adhesives have become accepted as stress-carrying features of construction. Before that glues were means of joining parts such as veneers on wood, for which load-carrying was not usually a requirement. This is still the case to a considerable extent. However, during the war the new adhesives produced proved their worth in construction of military aircraft. Bonding of nonmetallics, such as the rubber shock absorber in the skid strut for gliders, and the plies for the balsa-cored wood skin for the wooden bombers and fighters, was possible only because waterproof adhesives with a bond strength equal to riveted construction were available.

This thought — that adhesive bonding can be designed for load-carrying members as well as for simple joining of surfaces — has been taken up by industry, and is being developed with substantial benefit. There is no possibility of adhesive bonding completely replacing any other method of joining. It has its limitations, as has been indicated. It has, and will, make possible more flexible design, however, in that the engineer can now join many nonmetallics, and many metals to nonmetals. The composite materials, now so important to industry, are one result of this new freedom of design and fabrication. Savings in construction costs for present fabrications is another. The adhesive manufacturers are continually announcing new and improved bonding materials and formulations to make adhesive bonding even more valuable as a tool of production.

Acknowledgment

The help of technical men and publications of the following companies is acknowledged in the compiling of this manual:

Allied Chemical & Dye Corp., New York
American Cyanamid Co., New York
Angier Products, Cambridge, Mass.
Armour & Co., Glue Div., Chicago
B. B. Chemical Co., Cambridge, Mass.
Bakelite Corp., New York
Casein Co. of America, New York
Catalin Corp., New York
Cycleweld Div., Chrysler Corp., Detroit
Dow Chemical Co., Midland, Mich.
E. I. du Pont de Nemours & Co., Inc., Arlington, N. J.
Durez Plastics & Chemicals, Inc., North Tonawanda, N. Y.
Durite Plastics, Inc., Philadelphia
Furane Plastics Co., Los Angeles
General Electric Co., Springfield, Mass.
B. F. Goodrich Co., Akron
Interlake Chemical Corp., Cleveland
Minnesota Mining & Manufacturing Co., St. Paul, Minn.
Monsanto Chemical Co., Plastics Div., Springfield, Mass.
National Adhesives Div., National Starch Products Co., New York
Pennsylvania Coal Products Co., Petrolia, Pa.
Perkins, Glue Co., Lansdale, Pa.
Plaskon Div., Libby-Owens-Ford Glass Co., Toledo, O.
Resinous Products & Chemical Co., Philadelphia
Swift & Co., Chicago
Union Paste Co., Hyde Park, Mass.
U. S. Rubber Co., New York
U. S. Stoneware Co., Akron
Wilson & Co., Inc., Chicago

MATERIALS & METHODS Engineering File Facts

NUMBER 155
February, 1948

MATERIALS: Coated Abrasives
METHODS: Finishing

Coated Abrasives

Coated abrasives have become increasingly important as industrial finishing materials. In addition to their use in hand finishing operations for wood, metal, plastics, and other engineering materials, machines utilizing the peculiar advantages of coated abrasives (in the form of belts, disks, pads, etc.) are playing vital roles in reducing finishing costs. In discussing the characteristics of coated abrasives, there are three items to be considered: the abrasive, the backing, and the bonding agent.

Abrasives

The common types of grits used for coated abrasives are compared in Table 1. Abrasive grain sizes are compared in Table 2. Flint and emery coated materials are designated by grit size markings; garnet and aluminum oxide abrasives for woodworking have both the size numbers and the grading screen mesh numbers, while the artificial abrasive products are designated by the mesh numbers only. These screen mesh numbers denote the number of openings in the grading screen per lineal in. in both directions (i.e., a No. 50 screen has 50 apertures per in. in both directions, making 50 by 50 or 2500 openings per sq. in.). The same grading system is used for both the "technical" (garnet and artificial abrasives) and "nontechnical" (flint and emery) abrasive grains, but the grade sizes are not the same for both. Grade for grade, the technical grains are coarser than the nontechnical.

There are two main types of coatings or abrasive densities: open coating, to indicate coatings covering 50 to 70% of the surface with abrasive, resulting in increased flexibility and preventing loading of the paper or cloth. Closed coating completely covers the surface with abrasive grains. While the dense coating has a longer life and greater cutting efficiency than the open coating, it cannot be used on materials that would load or clog the abrasive.

Table 1—Abrasives Used in the Manufacture of Coated Abrasive Products

Abrasive Name	Type of Abrasive	Color	Field of Use	Standard Color Markings[1]
Garnet	Natural mineral product	Red	Sanding wood and wood finishing materials; best natural abrasive	Orange
Flint (Quartz)	Natural mineral product	Off-white	Flint paper sold by hardware and paint stores for handicraft and home workshop use; seldom used industrially	Green
Emery	Natural mineral product	Dull black	Oldest abrasive; used for some metal polishing; in other fields, replaced by synthetic abrasives	Red
Crocus	Natural (and by-product) iron oxide abrasive	Reddish-brown	Polishing soft metals	—
Aluminum Oxide	Electric furnace product	Brown	Machine sanding of hard wood, and general metal finishing; toughest, most durable abrasive	Yellow
Silicon Carbide	Electric furnace product	Dark gray to black	For finishing metals, paints and related materials, plastics, leather, glass; hand and machine use; hardest and most brittle of the abrasives	Blue

[1] *Sometimes used on the backs of coated abrasive products to identify the abrasive material.*

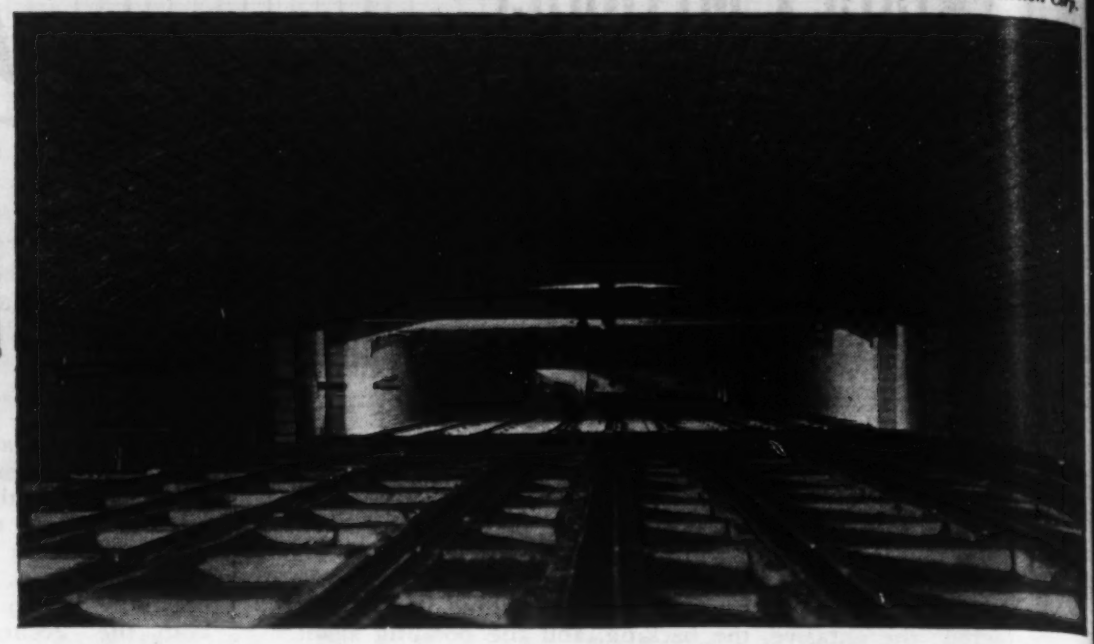
Table 2—Comparison of Grit Sizes Used for Coated Abrasives

Artificial Abrasives	Natural Abrasives			
Silicon Carbide and Aluminum Oxide	Garnet	Flint	Emery[2]	
600	—	—	—	
500	—	—	—	
400 or 10/0	—	—	—	
360	—	—	—	Very fine
320 or 9/0	—	7/0	—	
280 or 8/0	8/0	6/0	—	
240 or 7/0	7/0	5/0	—	
220 or 6/0	6/0	4/0	—	
—	—	3/0	—	
180 or 5/0	5/0	—	3/0	
150 or 4/0	4/0	—	2/0	
—	—	2/0	—	Fine
120 or 3/0	3/0	—	—	
—	—	0	0	
100 or 2/0	2/0	—	—	
—	—	½	½	
80 or 0	0	—	1	
—	—	1	1½	Medium
60 or ½	½	—	—	
—	—	—	2	
50 or 1	1	1½	—	
—	—	2	2½	
40 or 1½	1½	—	—	
—	—	2½	—	Coarse
36 or 2	2	—	—	
—	—	—	3	
30 or 2½	2½	3	—	
24 or 3	3	3½	—	
20 or 3½	3½	—	—	Very coarse
16 or 4	—	—	—	
12 or 4½	—	—	—	

[2] *Emery "Polishing Paper," used chiefly for metallographic polishing, is an especially fine grade of abrasive on blue paper backing; its grading and markings differ from the standard designations listed above.*

(Continued on page 107)

Photos courtesy Surface Combustion Corp.



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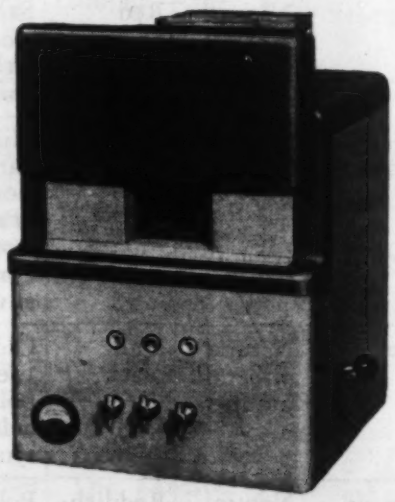

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Backing

Three common types of materials used for backing (material to which the abrasive grains are glued or bonded) are: paper, cloth, and composite. The features of each are listed in Table 3.

Glues

The abrasive grains are secured to the backings by means of glues or synthetic resins. For all dry sanding, high grade hide glue is used as the bonding agent. When the sanding is performed with water as a coolant, a waterproof adhesive is needed.

Glue is hygroscopic and if coated abrasives for dry work (*i.e.* abrasives made with hide glue) are kept in places where the humidity is too high or too low, their efficiency suffers. Coated abrasives stored in cool places where the relative humidity is 35 to 65% and used at about 50% relative humidity give the most satisfactory results.

Commercial Forms

A summary of the standard commercial forms in which coated abrasives are sold for industrial uses is contained in Table 4.

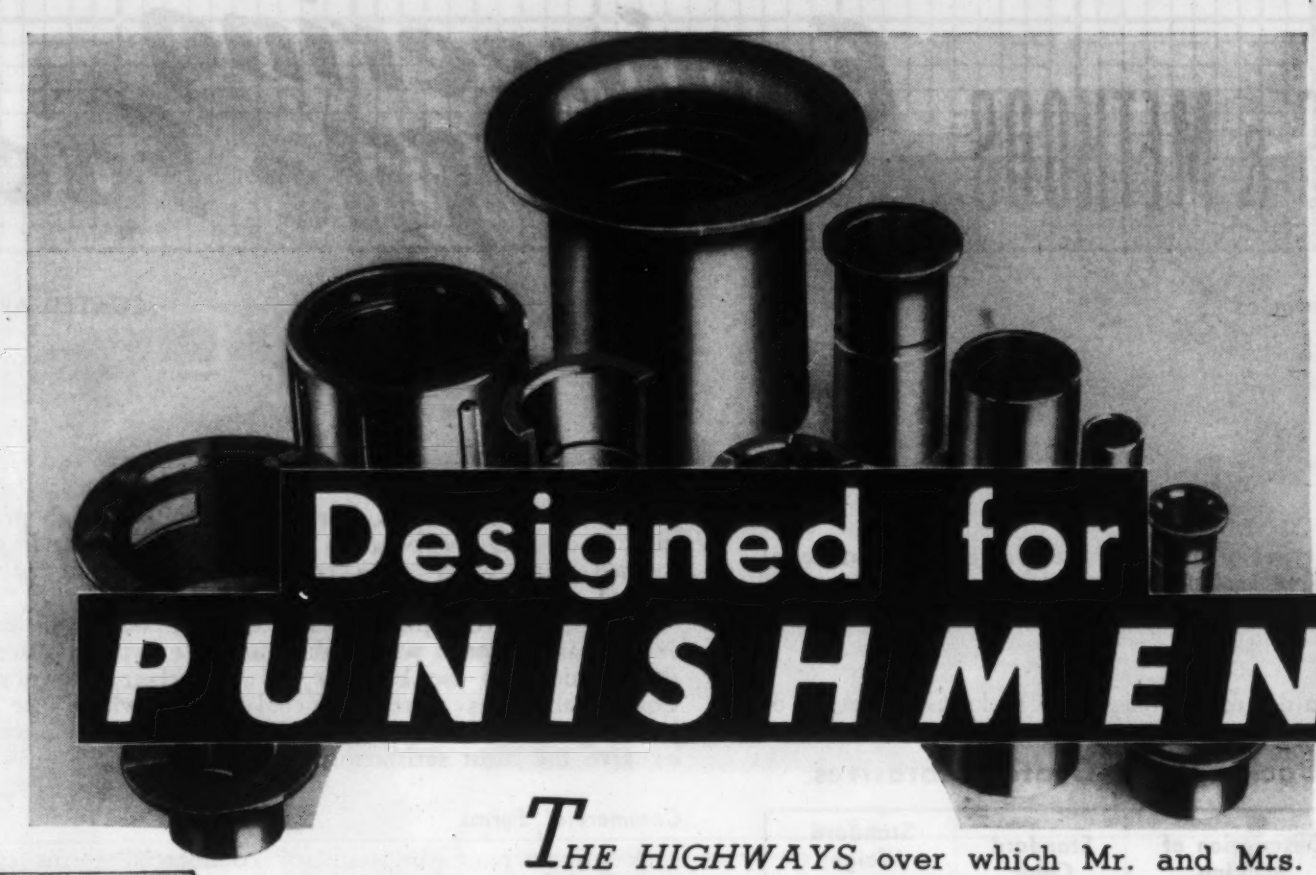
Table 3—Backings for Coated Abrasives

Type of Backing	Description of Backing	Standard Color	Standard Weight Designations
Paper Rope Paper	Contains rope fibres, which give it great strength — for rolls and belts	Natural (yellow-brown)	Finishing papers: "A" weight (very light) Cabinet papers: "C" weight (light)
Kraft Paper	Not as strong nor expensive as rope paper — largely for sheet goods		Cabinet papers: "D" weight (medium)
Jute Paper	Very flexible and soft — for such coated abrasives as pouncing paper (good abrasive for finishing felt hats)		Paper rolls and belts: "E" weight (heavy)
Cloth Jeans	Light weight flexible cloth for sheet goods for hand finishing	Brown—for cloth backed metal-working abrasives	"J" weight (jeans), light weight flexible cloth
Drills	For making abrasive belts, rolls, disks and some coarse-grit sheet goods	Blue—for silicon carbide, emery and crocus cloth backings White—for all wood-working abrasives	"X" weight (drills), heavier cloth than above
Combination Cloth	Made by glueing light cotton cloth to "E" weight paper; abrasive coated on cloth side	Natural paper color is visible	—
Fibre	For very heavy duty disks; cloth glued to vulcanized fibre		

Table 4—Commercial Forms of Coated Abrasives

Classification of Finished Goods	General Description	Remarks
Roll Goods	Maximum size of roll is 50 yd. long by original width (19-48 in.); slit widths as narrow as ¼ in. are obtainable. Paper roll widths range from ½-48 in. Cloth and combination roll widths vary from ½ to 28 in.	Rolls of emery and crocus abrasives generally made to order. Belts made from "X" cloth, combination, or rope paper ("E" weight) materials. Standard length and width belts made from roll goods and stocked by the manufacturers; special belts made to order.
Ream Goods	Sheets 9 by 11 in. are standard. Flint and emery sheets wrapped, or banded, in quires (24 sheets) and packed in reams (20 quires or 480 sheets = 1 ream). Other coated abrasive sheets wrapped or banded in quires, packed in ½ reams (240 sheets), then in reams (480 sheets). Flint paper sold in 8¾ by 10½-in. sheets. Small size (4½ by 5 in.) sheets made for retail sale.	Usually paper and cloth backed abrasives for hand use; some types of machinery (shoe making and repairing) also use sheets.
Specialties	Special size and/or shape sheets, disks, cones, sleeves and other special forms for sanding and high-speed finishing machines.	Disks for metal finishing made with fibre-combination backings; many slotted and mushroom disks, cones, sleeves, etc. are cloth backed abrasives.

Prepared by Robert S. Burpo, Jr. from data furnished by Behr-Manning Corp., Troy, N. Y., and the Clover Manufacturing Co., Norwalk, Conn.



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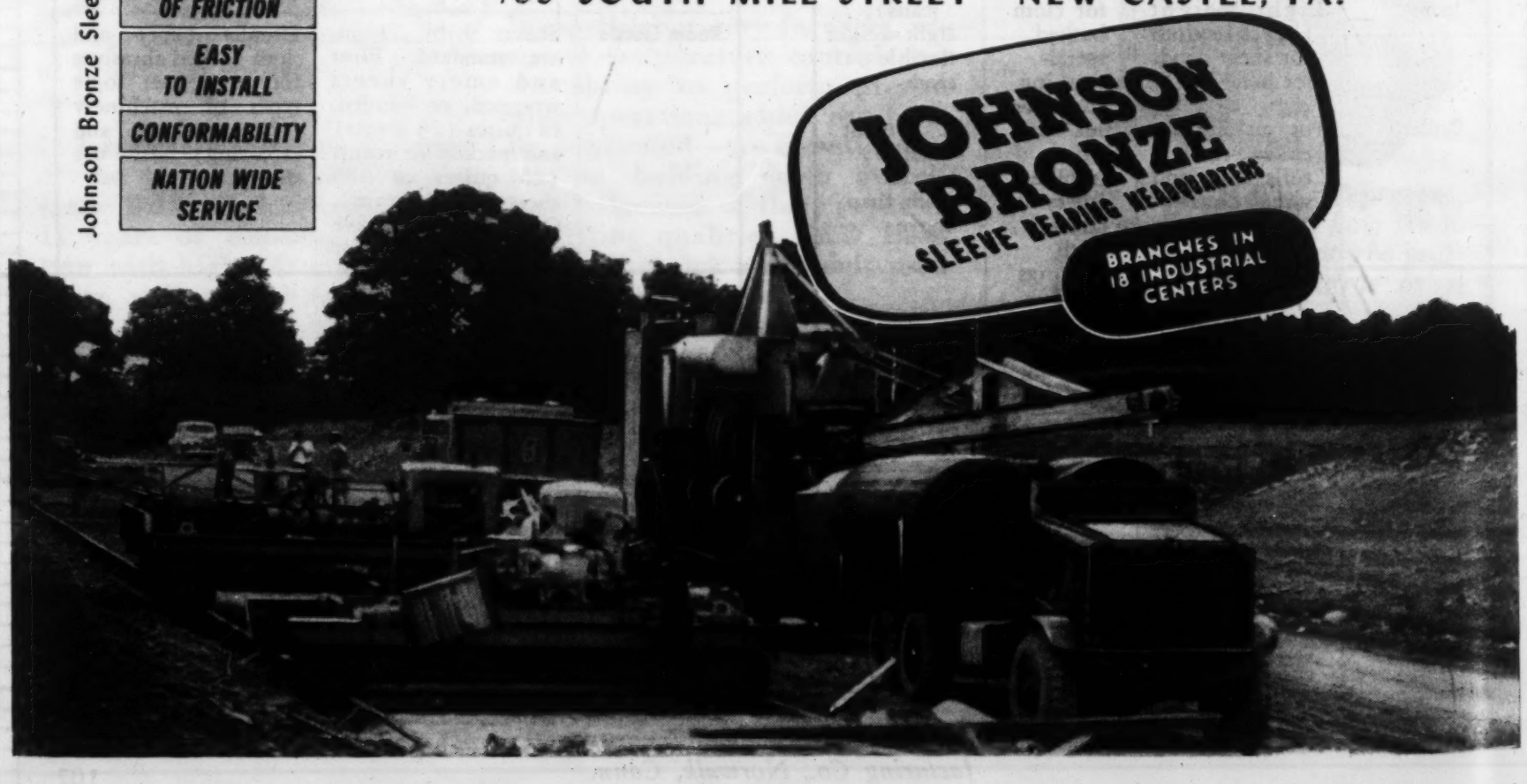

MATERIALS & METHODS

DIGEST

A selective condensation of articles—presenting new developments and ideas in materials and their processing—from foreign journals and domestic publications of specialized circulation.

Edited by H. R. CLAUSER

Chromate Passivation of Sprayed Zinc Coatings

Condensed from "Metal Treatment"

Sprayed zinc is extensively applied as a protective coating for iron and steel. It is an excellent base for organic finishes of all types and no chemical treatment is needed to guarantee adhesion of the organic finish.

The finish, however, is often applied to only part of the surface, while other portions are left bare for specific reasons, such as electrical contact. In these cases the bare zinc surface will tend to corrode under damp conditions. This is not objectionable from the protection point of view, but it detracts from the appearance and is undesirable electrically because it increases the contact resistance.

Therefore, in many applications zinc-sprayed coatings should be chromate passivated, as are electroplated zinc coatings. Before such a practice is adopted, various fundamentals should be considered. If the assembly includes riveted or spot welded seams, then the selection of the zinc spray process to avoid retention of chemicals in these seams is defeated by passivation, which requires the use of aqueous solutions. Also, it is known that the benefits of passivation are greatly diminished when stoved finishes are applied. Finally, the normal immersion times and acidity of the chromate solution may not be the most suitable for sprayed coatings.

A series of tests were made on zinc-sprayed steel panels, with and without chromate passivation, and with and without partial enamel coatings of cellulose and stoved synthetic base. The corrosion tests included cyclic tests and a mild fluctuating humidity test. Chromating is amply justified if bare surfaces that do not easily corrode are really essential, as, for example, where electrical contact is involved. Air-drying finishes should be employed to avoid any deterioration of the chromate passivated film. Nevertheless, when stoved finishes have to be used, appreciable value is still retained in the chromate film.

Normal chromate processes can be employed on sprayed zinc, although some work is desirable to establish the optimum conditions. Chromate passivation does not materially add to the surface contact resistance of zinc in its clean "metallic" condition. This resistance is lower than for corroded zinc. The chromate treatment can therefore be employed where phosphate treatments are unsuitable. (E. E. Halls. *Metal Treatment* (British), Vol. 14, Autumn 1947, pp. 164-168.)

Passivation of Stainless Steels

Condensed from "Métaux et Corrosion"

A study was made of the passivation of stainless steels in an attempt to develop a procedure that could be used commercially to produce a stable passivity in corrosive sulfuric acid solutions. Most of the tests were made on an 18 chromium-8 nickel-3% molybdenum and an 18 chromium-10% manganese steel. Both electrical and chemical methods were included.

Of the electrical methods, excellent results were obtained using 20 to 40% sulfuric acid as the electrolyte. Since the metal is normally attacked by these solutions, it is necessary to make the sample anodic at the start of the immersion. The current necessary for protection may be progressively lowered and, when it reaches zero, a stable passivity is obtained.

With a chemical method, passivity may easily be developed by a sufficiently long treatment in dilute nitric acid. This treatment, however, may lead to pseudo-passivity when applied to a sand blasted surface. In such cases, the pseudo-passivity may suddenly disappear with the initiation of severe corrosion. Stable passivity requires preliminary "sensitization" by acid corrosion of the surface. Sensitization is done in a series of acid treatments, the last of which is preferably a solution containing 10% nitric acid and 2% sodium fluoride.

Sensitization and passivation occur simultaneously in the anodic method but successively in the chemical method. They are considered to be two aspects of the same property; both are destroyed in vacuum at 750 to 1110 F. Sensitization modifies the surface to a certain depth but is not destroyed by a light superficial abrasion. Passivation is resistant to minor local damage but is completely eliminated by light sanding.

These chemical and anodic treatments give a stable and durable protection to stainless steels in all concentrations of sulfuric acid up to a limiting temperature, which depends upon composition. Semi-industrial tests have shown remarkable results when these treatments have been applied to finished parts. (L. Guitton. *Métaux et Corrosion* (French), Vol. 22, Apr. 1947, pp. 47-60; May 1947, pp. 81-89.)

Tarnishing of Metals

Condensed from "Sheet Metal Industries"

The growth of oxide or sulfide films on metals may obey various laws. When cracks, pores or other cavities appear, parabolic, rectilinear or logarithmic equations can apply. In the absence of such complications, a parabolic law is generally expected.

Certain equations expressed in terms of the electrical properties of the film indicate that a film substance with a high electrical resistance is likely to confer good resistance against oxidation and tarnish. It now be-

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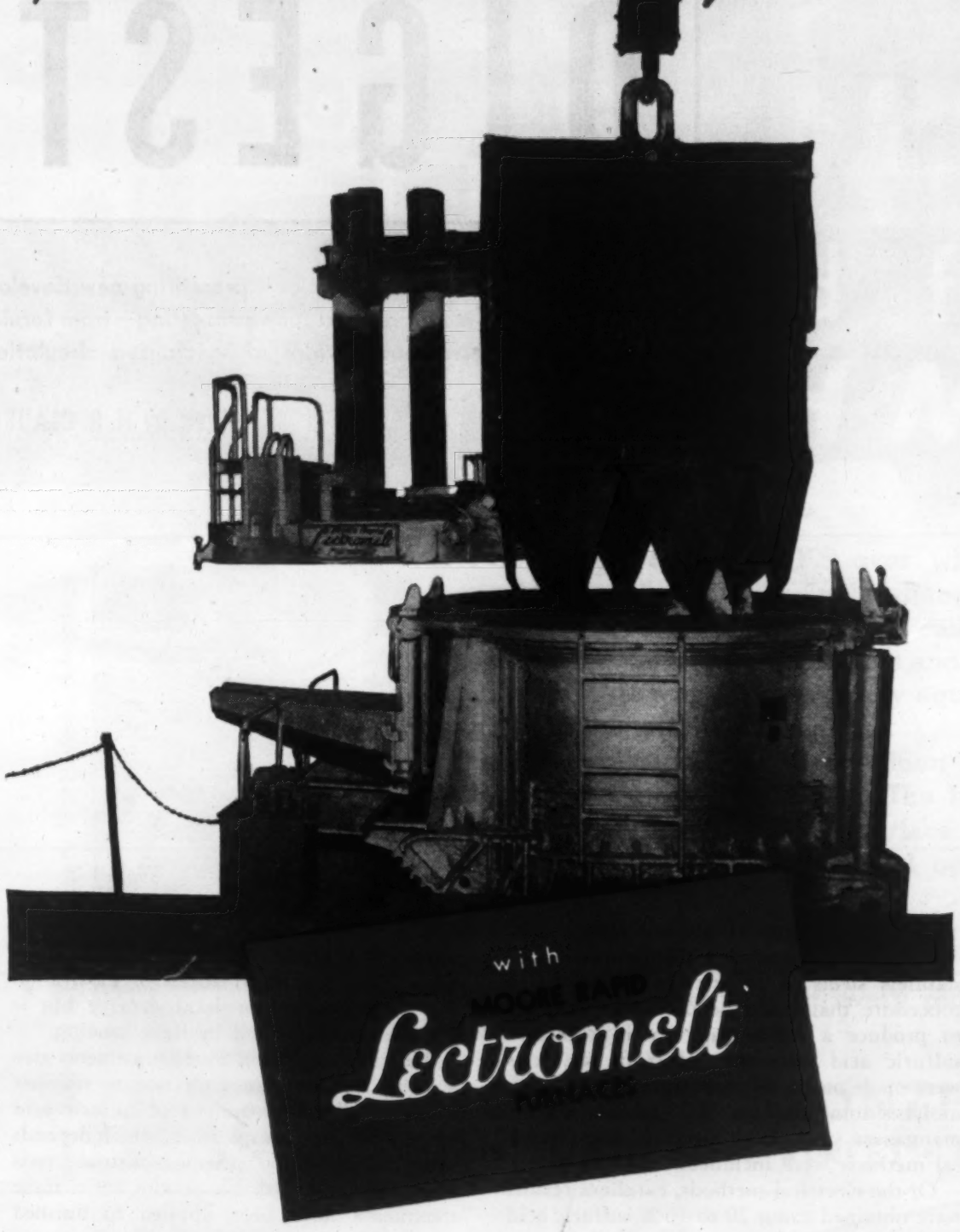

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DIGEST

comes evident why films of alumina or beryllia, substances of high electrical resistance, often give admirable protection to the metal. Films thicken quickly and are non-protective only if the film has both electronic and ionic conductivity. Sulfides contain more lattice defects than oxides, so the presence of sulfur in a film reduces its protective properties.

The "selective oxidation" method has been shown to improve greatly the resistance of a copper—5% aluminum alloy to oxidation at high temperatures and of a silver—6.5 copper-1% aluminum alloy to tarnishing in sulfur-polluted air at ordinary temperatures. In this method, the alloy is heated in a hydrogen atmosphere so as to develop an invisible film of pure alumina (free from copper and silver) on the surface.

This method, however, is impracticable for electroplaters and for the protection of the ordinary silver-copper alloy. In these cases, a beryllia film can be deposited on silver by the electrolysis of a solution of beryllium sulfate containing ammonia. The silver then has a considerable resistance to tarnishing, although this does not last indefinitely. (U. R. Evans. *Sheet Metal Inds.* (British), Vol. 24, Nov. 1947, pp. 2189-2193; 2205.)

Welding Developments

Condensed from Papers of the American Welding Society

The technical sessions of the American Welding Society at the Metal Show last October covered practically all the important phases of welding. Below are digested a number of important papers presented at these technical sessions.

Hidden Arc Welding

In recent years submerged or hidden arc welding has received considerable attention because it offers a rapid, automatic production welding method. A couple of papers dealing with the use of this process for welding low alloy steels were presented.

One of these papers, by E. A. Clapp & E. L. Frost of the Union Carbide & Carbon Research Laboratories ("Submerged Melt Welding of Hardenable Steels"), discussed some of the methods used in welding of hardenable steels, with particular emphasis

on the control of cooling rates of welded assemblies as affected by preheat temperatures and welding conditions.

Frequently, certain types of high-carbon, low-alloy steels are sensitive to cracking and can develop excessively high hardness. To overcome these difficulties, varying degrees of preheat and, if necessary, postheat can be used. Isothermal transformation curve data can be used to determine the proper preheat and postheat temperatures, and by regulating welding speeds and currents, the cooling rates can be controlled so that undesirable metallurgical changes will not take place in either the heat-affected zone of the base metal or in the weld metal.

The submerged arc process has a wide operating range and so provides a flexible means of controlling cooling rates. The process also provides close control of weld metal composition. These features make it adaptable to the welding of hardenable steels. The method has been successfully used to weld many alloy steels such as chromium-nickel, chromium-molybdenum, nickel, molybdenum and chromium-vanadium steels. It has also been applied to welding high-carbon abrasion-resistant steels and even to steels having air-hardening properties.

Another paper on the hidden arc welding process, by H. E. Cable of the Lincoln Electric Co. ("Composite Alloy Fabrication with the Hidden Arc"), discussed the hard-facing of wear and corrosion resistant parts.

Probably the most common cause of failure, both in the repair of fractures and in surfacing, is underbead cracking and embrittling of readily hardenable alloys. Because of the relative freedom from hydrogen and some other aspects of the hidden arc process, the sensitivity of hardenable steels to cracking is lessened. Sound deposits of high-alloy content can be made at such low preheat temperatures as to induce high quench hardness in the deposit without cracking.

This is significant in the surfacing of many parts such as rolling mill back-up rolls. These heavy rolls must have high tensile and fatigue strength in the core or mandrel while the surface must be hard to resist crushing action. The subsurface must be hard enough to support the surface. By using the hidden arc process for surfacing the rolls, it is believed that quench hardening of the surface layer during deposition, followed by a mild draw obtained as subsequent layers are deposited, will give a harder surface with less alloy which will be relatively less hardened by working. In this way there will be a lesser difference between the surface hardness and that of the supporting layer for a given amount of

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The Nominal Analysis and Nominal Physical Properties of one of these, Circle Ⓛ 22, are given at left. However there are many variants of this approximate analysis which make possible its successful application to a wide range of service conditions. They are summarized on the new Circle Ⓛ Alloy Data Sheet, sent upon request.

LEBANON CIRCLE Ⓛ 22

NOMINAL ANALYSIS

Carbon Max.	0.07
Silicon	1.25
Manganese	0.75
Chromium	19.50
Nickel	9.00

NOMINAL PHYSICAL PROPERTIES

Tensile Strength	75,000
Yield Point	36,000
Elongation in 2"—%	50
Brinell Hardness	135

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ALLOY AND STEEL

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DIGEST

working. This means more tonnage rolled between roll dressings, which is an economy.

The most advanced trend in surfacing with alloys is the use of fabricated electrodes wherein the desired alloy deposit is alloyed in the arc from semirefined ores at substantially lower cost than by using the finished alloy wire.

Pressure Welding

An important paper was delivered by N. H. Cuke of the Canadian Liquid Air Co., Ltd. on the relatively new open-butt pressure welding process ("Multiple Flame Pressure Welding Process"). In this process the parts to be joined are held a short distance apart and heated by a multi-flame oxy-acetylene burner to actual surface melting temperature. The faces are then brought together and pressure is applied to complete the joint. This is distinctly different from the closed-butt pressure welding method in which the abutting faces are in contact with each other during the heating cycle.

The open-butt process has the advantage over closed-butt pressure welding of not requiring great care in preparing the weld faces. In addition, there is less likelihood of oxidation occurring in the weld because the weld faces are in a protective reducing atmosphere during the heating cycle.

Open-butt pressure welding is also faster, resulting in much lower consumptions of oxygen and acetylene. Because the weld faces are heated mainly by direct radiation and convection from the flames, the entire weld faces can be heated very evenly as compared to closed-butt welding where the heating is mainly by conduction. Thus, a substantial temperature gradient on the weld faces is difficult to eliminate.

A series of tests were conducted on welding low-carbon steel by this process and the results were very successful. In addition to welding sections of the same thickness, steel sheets or plates of different thicknesses can be joined by the open-butt method with good metallurgical and physical properties. Although these tests were confined to low-carbon steels, further work should expand this welding process to other metals and alloys. (For further details on the process, see "Open-Butt Pressure Welding of Steel", MATERIALS & METHODS, Jan. 1948.)

Inert-Arc Welding

The inert-arc process is one of the fastest growing methods of welding in industry today. R. W. Tuthill of the General Electric Co. reported on the latest technical aspects and applications of the process ("New Applications of Inert-Arc Welding").

In this welding process a nonconsuming

DIGEST

electrode holds the welding arc in an atmosphere of inert gas. No flux is used and in many applications no filler metal is required. Either argon or helium gas are used, depending on the characteristics of the particular job and the results desired.

The different applications of this process are almost too numerous to mention. Among them are the welding of Fernico, an alloy with the same coefficient of expansion as glass and used in electronic tubes; the welding of silicon steel sheets, used in transformers; repair of aluminum castings, fabrication of refrigerators, manufacture of extruded window frames; welding of ice cream molds; and many others.

The inert-arc process will produce a strong, sound, good appearing weld at high speed on any application where a minimum of filler wire is added. It should be superior to most present welding methods for these applications. There is no common joint design on which the inert-arc process has not produced a satisfactory job. The process can be applied manually or with a machine with or without automatic arc control.

Argon gas is used to weld aluminum and magnesium with alternating current, and light gage alloys with direct current, straight polarity. Helium gas may be used to weld magnesium, with reverse polarity and most other metals, using direct current, straight polarity. Metals that have been welded with this process include aluminum, magnesium, copper, Inconel, Everdur, beryllium copper, stainless steel, Fernico, molybdenum, high zinc alloys, silicon steel and enameling iron.

Stud Welding

Electric arc stud welding, which was developed in the late thirties and saw such wide use during the war, was described in detail by R. C. Singleton of the Nelson Sales Corp. ("Electric Arc Stud Welding").

Basically, the process consists of two steps: (1) developing heat by drawing an arc between the stud (electrode) and the plate to which it is to be welded, and (2) bringing the two pieces into intimate contact when the proper welding temperature is reached.

Stud welding applications may be placed in two categories, depending upon the stud welding unit being used: production applications where the work is brought to the stud welder, and applications where a portable or hand gun is carried to the work. In principle the production and portable units are the same. However, the production welder is mounted on an automatic positioning device which permits very careful control of stud location. Tolerances of ±0.005 in. on location and ±0.010 in. in height are possible.

MORE and more important fabricators, who regularly specify Murex electrodes to obtain superior welds, are discovering there are extra dividends when M & T accessories are on the job too.

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DIGEST

The greatest use for the stud welder is in applications where portability of equipment is a dominating factor. The heating and boiler industries are making wide use of stud welding. It is also being used in the building of locomotives and railroad cars.

Magnesium in Germany, 1939-1945

Condensed from "Metal Treatment"

Little fundamental research was carried out in Germany during the war, but certain improvements in production were made. A limited amount of work was done on new alloys, including magnesium-cerium-zinc cast alloys, magnesium-manganese-mercury wrought alloys and magnesium-manganese-thorium alloys.

Lightly calcined basic magnesium carbonate instead of the standard calcined magnesite gave encouraging results in a pilot-plant conversion to anhydrous magnesium chloride for use in the electrolytic cells. A development regarded as of major importance was the "Elfinal" process, involving the grain refinement of magnesium-aluminum-zinc alloys by means of anhydrous ferric chloride additions to the melt, rather than by superheating.

Most of the die castings were made in hot-chamber pressure die casting machines. For small die castings, a piston type machine was used and, for larger parts, an air pressure machine. Water cooling methods of billet casting were evolved on a considerable scale. The pre-war difficulties were overcome by the addition of 0.004 to 0.005% beryllium to inhibit oxidation without grain coarsening, by the use of a new thin-walled mold and by careful control of operating conditions.

The combination of a water-cooled die and dummy block and a gradient heated billet gave the best results in extrusion with much reduced discard. Magnesium-manganese alloys were successfully rolled on heavy mills with large reductions. With proper forging practice, magnesium forgings proved quite practicable not only for aircraft but also for heavy vehicle and railroad wheels. Progress in welding was not spectacular. Little fundamental change occurred in protection against corrosion.

The war-time applications were largely in the aircraft field. Forgings were used fairly extensively as well as castings, sheet and extrusions. Magnesium was applied widely in the Volkswagen and in certain special army equipment. An interesting

DIGEST

example of the experience gained with magnesium alloys was represented by passenger trailers, some of which had seen very arduous service and were in excellent condition even after many years use. (F. A. Fox. *Metal Treatment* (British), Vol. 14, Autumn 1947, pp. 169-174.)

Uses of Rhodium

Condensed from "Metal Industry"

Rhodium finds its principal use in the electrodeposited form since its fabrication presents considerable difficulty. The main applications can be classified into three principal groups.

The first group involves the use of electrodeposited rhodium as a permanent protective finish against corrosion. Rhodium is completely resistant to attack by nearly every common acid, including aqua regia; the only corroding agent which readily attacks it is fuming sulfuric acid at 570 F. Rhodium plating for this purpose is used on scientific instruments, camera fittings, radio equipment and similar apparatus.

In the second group, rhodium is used as an electrical contact surface, particularly in radio frequency circuits. Its ability to maintain a low and stable contact resistance is of exceptional value where there is no appreciable voltage and where absolute reliability is essential.

The third group consists of the use of rhodium as a reflecting surface in either the visual or infra-red range of radiation. Its high optical reflectivity is somewhat inferior to that of freshly polished silver and gold. The reflectivity of silver, however, diminishes appreciably due to tarnish, whereas that of rhodium is constant. Gold is soft and easily damaged, while electrodeposited rhodium has a high hardness of about 775 to 820 Vickers.

Rhodium can be deposited directly on silver, nickel and copper alloys, but a preliminary deposit, preferably silver, is needed with tin, lead, zinc, cadmium, aluminum, iron and steel. Where operation at high temperatures is involved, nickel is preferred to silver. The thickness of the rhodium deposit depends on the service, 0.000015 to 0.00002 in. being generally adequate for protection against tarnish. However, 0.001 or 0.002 in. may be needed for very adverse conditions of corrosion, severe mechanical wear or heavy pressures. (L. B. Hunt. *Metal Ind.* (British), Vol. 71, Oct. 24, 1947, pp. 339-342.)

If you're finishing parts with JUST PLAIN ZINC ...better read this!

You've probably noticed that, despite today's grab-bag markets, more and more complaints are coming in on untreated zinc parts. Assemblers are demanding protection on all their zinc plate items — from refrigerator shelves to small tools; from fasteners to radio chassis.

So, for a protective treatment that will pass your customer's approval use Luster-on* inhibited zinc bright dip. Inexpensive, easy to use Luster-on* makes any zinc plate passive. A simple Luster-on* dip at the end of your plating line gives your product a finish that is permanently bright, rust- and corrosion-proofed — that even resists handling-smudges and fingermarks. Once your product is cold-dipped in Luster-on* there's no danger of spoiling its overall beauty or utility value.

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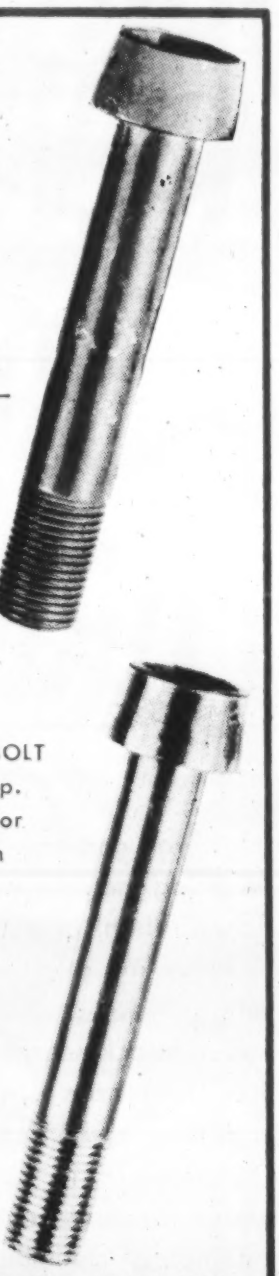

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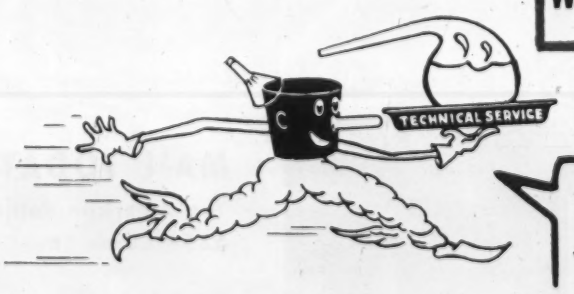

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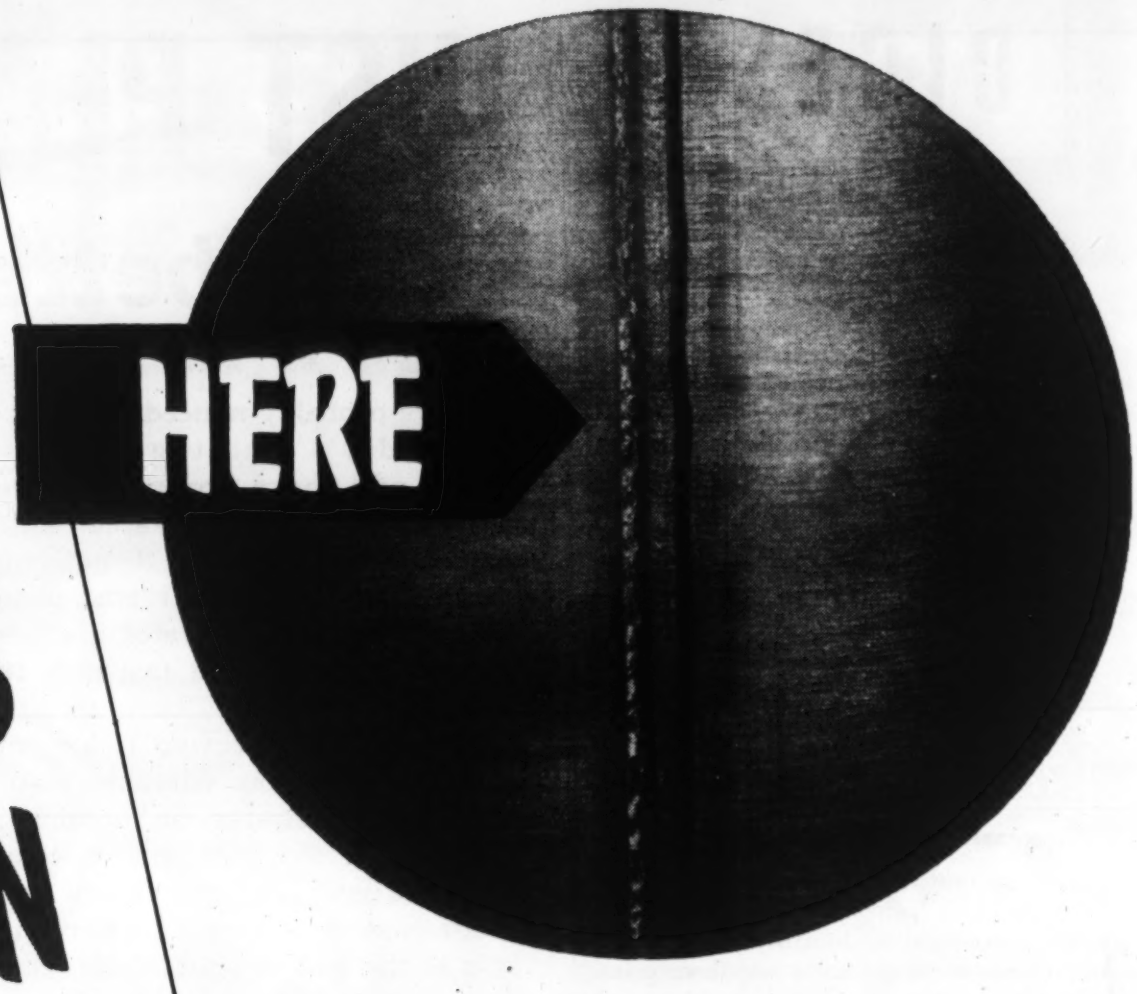

Now you can save money and avoid future service troubles by using the new ARMCO Stainless Steel Type 316 ELC (Extra Low Carbon) in welded processing equipment.

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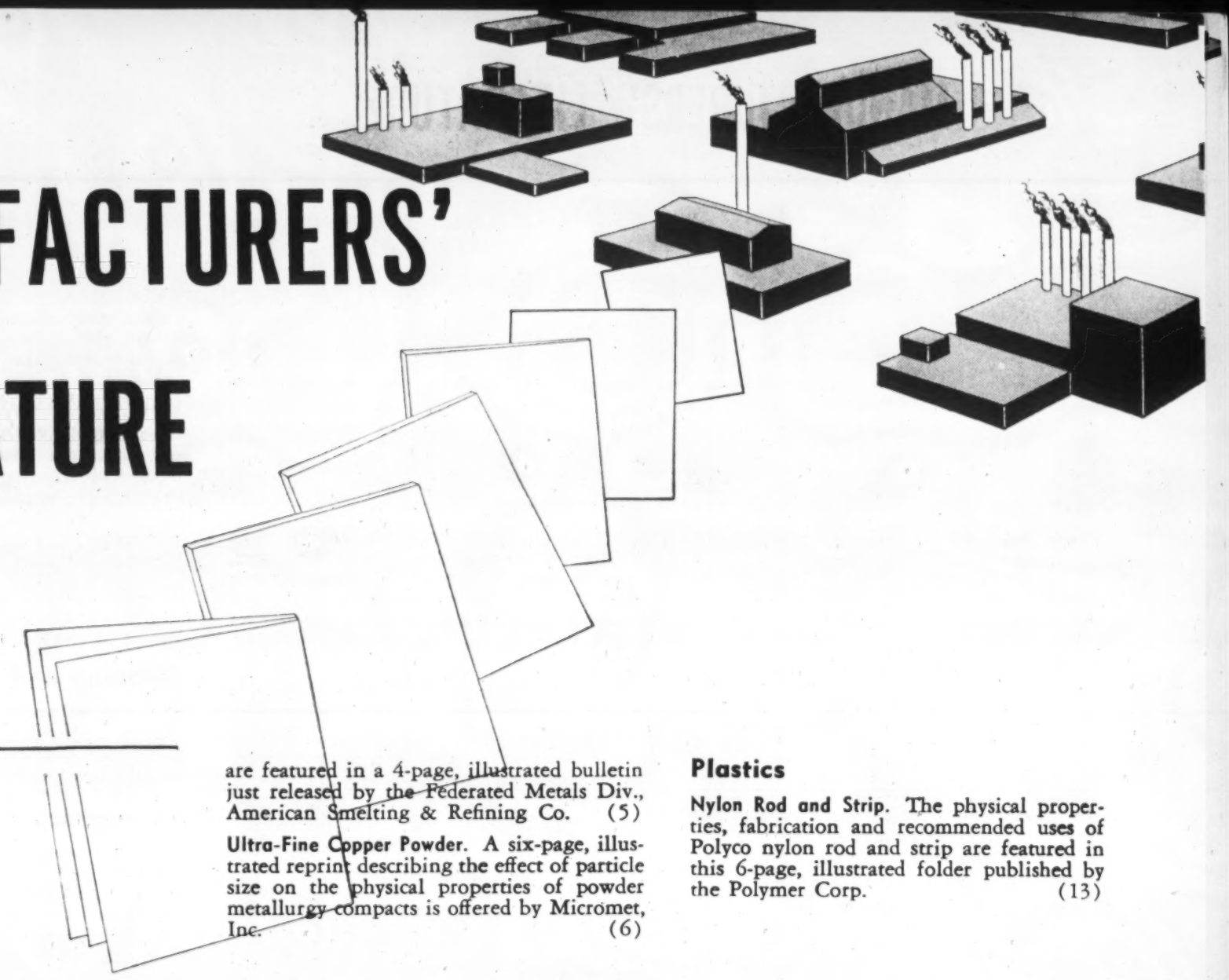


Materials

Iron and Steel

Machining Stainless Steels. Complete data on the machining of Armco stainless steels, including cutting rates, tool composition, and suggestions for correct grinding, milling and drilling are presented in an attractive, 38-page, illustrated catalog, issued by the American Rolling Mill Co. (1)

Nonferrous Metals

Aluminum Casting Alloy. The properties, composition and advantages of Acme Almag 55, a new high-tensile aluminum casting alloy with elongation values from 20 to 30%, are discussed in an 8-page, illustrated bulletin offered by Acme Aluminum Alloys, Inc. (2)

Beryllium-Copper Alloys. Recommended working stresses, physical properties and constants for two classes of beryllium-copper alloys—high-strength Berylco 25 and Berylco 165, and high-conductivity Berylco 5—as well as selection of the alloy, condition, temper, suggested heat treating equipment and practices, etc. are all discussed in a 4-page data sheet, No. 8, published by the Beryllium Corp. (3)

Tantalum. The physical, chemical and electrical properties of tantalum, and its workability, weldability, machinability and fabricating techniques are all discussed in this attractive, 20-page, illustrated bulletin offered by Fansteel Metallurgical Corp. (4)

Aluminum Alloy. The properties, composition and characteristics of a new aluminum casting alloy, Tenzaloy (F 100.4Zn), which produces castings with heat treated properties without the expense of heat treatment, are featured in a 4-page, illustrated bulletin just released by the Federated Metals Div., American Smelting & Refining Co. (5)

Ultra-Fine Copper Powder. A six-page, illustrated reprint describing the effect of particle size on the physical properties of powder metallurgy compacts is offered by Micromet, Inc. (6)

Parts and Forms

Stainless Steel Castings. Typical applications, characteristics and analyses of a variety of stainless steel castings and stainless precision castings produced by the Cooper Alloy Foundry Co. are presented in this 8-page, illustrated bulletin. (7)

Aluminum Extrusions. Complete data on extruded aluminum, rods, bars, tubing, hollow sections, and special shapes for structural, architectural and decorative purposes, in any shape that will fit within a 10-in. circle, are presented in a 2-page, illustrated preprint offered by the Harvey Aluminum & Brass Div., Harvey Machine Co., Inc. (8)

Steel Tubing. Typical applications, specifications, and tables of round tubing weight per lineal foot, round tube tolerances, gage tolerances, etc. are featured in this 2-page, illustrated catalog published by the Jones & Laughlin Steel Corp. (9)

Industrial Wire Cloth. A complete line of metallic filter cloth, woven wire cloth, fabricated wire parts, metallic bolting cloth, A.S.T.M. testing sieves, and testing sieve shaker is covered in this 4-page, illustrated bulletin just released by the Newark Wire Cloth Co. (10)

Cold-Rolled Steel Specialties. A wide variety of special applications made from cold-rolled steel—unannealed, annealed, or hardened and tempered—are listed in this 4-page, illustrated, pocket-size folder offered by Sandvik Steel, Inc. (11)

Castings. Specifications and the mechanical properties of a variety of magnesium, aluminum and gray iron castings are featured in this 4-page, illustrated bulletin, issued by the Utica Radiator Corp. (12)

Plastics

Nylon Rod and Strip. The physical properties, fabrication and recommended uses of Polyco nylon rod and strip are featured in this 6-page, illustrated folder published by the Polymer Corp. (13)

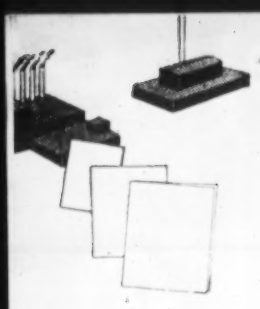
Methods and Equipment

Heat Treating

Induction Furnaces. The advantages, principles of operation, specifications and performance data of 20- and 40-kw. spark-gap converters used for a wide variety of induction melting, heating, brazing and hardening applications are presented in a 16-page, illustrated bulletin, No. 14-A, available from the Ajax Electrothermic Corp. (14)

Furnaces for Carburizing and Gas Cyaniding. This 28-page, illustrated catalog, No. T-623, discusses the use of Homocarb furnaces for obtaining not only precision carburizing at low cost, but also precision gas cyaniding, produced by the Leeds & Northrup Co. Complete specifications are included. (15)

Heat Treating Equipment. A complete line of soaking pits, slab and billet heaters, normalizing and annealing furnaces, annealing covers, stress relieving furnaces, prepared gas atmosphere generators, wire patenting furnaces, etc. for use in any type of heating application or heat treatment are profusely illustrated and described in a 32-page catalog offered by the Surface Combustion Corp. (16)



MANUFACTURERS' LITERATURE

Welding and Joining

Hard Surfacing Steel Electrode. Typical applications and specifications of Amsco Toolface, a super hard and tough alloy tool steel welding rod, as well as complete data on welding procedures and heat treating are all included in a 4-page, illustrated bulletin, No. 947-W, just released by the American Manganese Steel Div. of the American Brake Shoe Co. (17)

Arc Welders. A new 36-page, illustrated catalog containing descriptions, dimensions and specifications of a complete line of Simplified electric motor-driven d.c. welders, gasoline engine-driven welders, a.c. transformer type welders, welding generators, etc., is offered by the Hobart Brothers Co. (18)

Transparent Adhesive. This single sheet discusses Dyna-Clad 1800, a transparent adhesive that permanently bonds plastics, glass, ceramics, leather, cloth and paper, and is particularly effective in bonding acetate, urea and methacrylate plastics, offered by the Merchants Chemical Co. Prices are included. (19)

Acetylene Generators. Specifications and prices are included in this 6-page, illustrated folder, No. A-847, covering a variety of Model A acetylene generators for use in industrial plants where a large quantity of acetylene is needed for production welding or cutting. Sight Feed Generator Co. (20)

Welding Presses. Both air- and motor-operated types of welding presses, Models A2, A3, M2 and M3, and the new medium-duty universal seam welder are described and illustrated in this 4-page bulletin, No. 11, published by the Thomson Electric Welder Co. (21)

Cable Connections for Electric Welding. A complete line of electrode holders, ground clamps, cable connectors, machine terminals, cable splicers, lugs, and carbon holders are listed in this 12-page, illustrated catalog, No. 1948-T, offered by the Tweco Products Co. Specifications and prices are included. (22)

Forging and Forming

Power Presses. A variety of power presses manufactured by the E. W. Bliss Co. during the past year, including a briquetting press, triple-action toggle press, single-crank toggle press, etc., are described in this 4-page, illustrated bulletin. (23)

Scrap Cutter, Stock Feed, Etc. This 4-page bulletin with 2-page insert, both illustrated, features the Model D-611 scrap cutter, Model D-600 hydraulic stock feed, and Model D-610 stock straightener for use on punch presses with all stock to 3/32-in. thickness and 4-in. width, produced by the Haller Machine & Mfg. Co., Inc. Specifications and prices are included. (24)

Preform Press. The Model 294 Dual-Pressure Preformer, a new preform press that applies pressure simultaneously from above and below, is described and illustrated in this 4-page bulletin, No. 488, offered by the F. J. Stokes Machine Co. (25)

Machining

Grinding Wheel Dressers. A complete line of diamond-impregnated cemented carbide grinding wheel dressers, available in three standard nib sizes for wheels ranging from 16-in. dia., 1½-in. width to 42-in. dia. and 8-in. width, are discussed in an 18-page, illustrated booklet, No. DR-480, offered by the Carboloy Co., Inc. (26)

Vertical Milling Machine. The No. 0-8 vertical milling machine produced by the Cincinnati Milling Machine Co. is described and illustrated in this attractive 16-page bulletin, No. M-1532. Detailed specifications are included. (27)

Small Tool Grinder. The new G-3 grinder for more efficient small tool grinding, as well as deburring, buffing, polishing and numerous special applications, and featuring rapid change wheel arbors, triple speed selection, precision spindle, etc., is described and illustrated in a 4-page bulletin just released by the Corlett-Turner Co. Specifications are included. (28)

Rotary Files. More than 100 types of high-speed and tungsten carbide rotary files, each illustrated in actual size for easy selection of the correct fluting and shape, are featured in this 12-page bulletin, No. RF-101, just issued by the Charles L. Jarvis Co. Specifications are included. (29)

Cutting Tools. A complete line of high-speed midget mills, with their complement of junior mills, lab mills, carbide midget mills, die mills, fin mills and micro-mills, are described and illustrated in a 12-page bulletin, No. 16-M, published by Severence Tool Industries, Inc. Specifications and prices are included. (30)

Metal Cutting Saw Blades. A useful wall chart illustrating the proper hand, band or power saw blade to use to cut any type metal, the right and wrong way to use a metal cutting saw blade, and how to overcome common metal cutting troubles, is offered by Victor Saw Works, Inc. (31)

Centering Machines. Three types of centering machines—the single spindle, single head type; the single spindle, single head, lever feed type; and the single spindle, duplex type—are all illustrated and described in this 4-page bulletin issued by the Whiton Machine Co. Complete specifications are included. (32)

Cleaning and Finishing

Corrosion Resistant Coating. Iridite, a quick dip process for corrosion resistance as a paint base or final finish on all zinc or cadmium surfaces, is discussed in a 4-page, illustrated bulletin offered by Allied Research Products, Inc. (33)

Weather-Resistant Coating. Typical applications of Dum Dum Masonoc, a new coating that provides a tough but elastic and pliable weather-resistant, water-repellent coating for use on both new or uncoated metal structures and over previously-cooled surfaces, are discussed in a 12-page, illustrated bulletin just released by the Arco Co. (34)

Plastic Protective Coating. The present and potential applications in the metal-working industries of Liquid Envelope, a peelable plastic film of protection produced by Better Finishes & Coatings, Inc., are discussed in a 12-page, illustrated bulletin. (35)

Plating Barrels. A wide range of standard and I.D. Mercil type plating barrels, from the small single-unit jewelers' apparatus to the large multiple-unit production installation, are described and illustrated in a 20-page bulletin, No. PB-107, offered by the Hanson-Van Winkle-Munning Co. Complete specifications are included. (36)

Aluminum and Bronze Powder and Paste. A list of all the grades of Magnaflake aluminum and bronze powder and paste manufactured by the Magna Manufacturing Co., Inc. is featured in this 4-page, illustrated bulletin. (37)

Metal Parts Degreasers. A new complete line of vapor, vapor spray, and liquid-liquid vapor degreasers for the degreasing of metal parts are described and illustrated in this 6-page folder, No. 7E1, offered by the Optimus Equipment Co. (38)

Protective Coating. Unichrome Coating 218, an elastic baking synthetic, the thickness of which can be varied by application method for use on any parts or equipment that need extra-tough coatings, is discussed by United Chromium, Inc. in their new, 4-page, illustrated bulletin, No. RC-1. (39)

Inspection and Control

Heat Distortion Tester. A new tester for determining the heat distortion of plastics,

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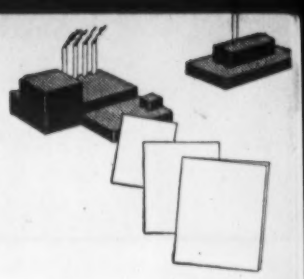

that tests as many as four specimens simultaneously, and has automatically controlled temperature rise, is described in a 3-page, illustrated pamphlet, published by the American Instrument Co. (40)

Diffraction Grating. This single sheet, offered by Baird Associates, Inc., describes and illustrates a diffraction grating for producing transparent plant grating replicas required as calibration specimens in electron microscopy. Price is included. (41)

Creep Testing Machine. A new creep testing machine of 12,000-lb. capacity for testing conventional specimens at high temperatures, produced by the Baldwin Locomotive Works, is described and illustrated in a 2-page bulletin, No. 272. Specifications are included. (42)

Thermocouples, Pyrometer Accessories, Etc. Bulletin No. P 1235, just released by the Bristol Co., describes and illustrates a complete line of thermocouples, pyrometer accessories and protection tubes, and includes prices covering the pyrometer accessories. (43)

Moisture Determinator. This 4-page bulletin published by the Harry W. Dietert Co. describes and illustrates the Model 285 Moistmeter, a new portable electric moisture determinator for rapidly determining the moisture in sand or floor or in sample container or sand bins. Specifications are included. (44)

Timing Motors and Devices. A complete line of synchronous timing motors, timing devices and clock movements produced by the Haydon Manufacturing Co., Inc. are described and illustrated in this 16-page catalog, No. 320. Specifications and typical applications are included. (45)

Rotary Piloting Fixture. This 2-page, illustrated bulletin, available from the Physicists Research Co., discusses the Type RA rotary piloting fixture for providing the tracing motion needed for making surface roughness measurements with the Profilometer around internal and external surfaces of rotation, such as cylinders, spheres and toroids, and on circular flat surfaces such as rings, grooves and bosses. Specifications are included. (46)

Spectrophotometers. Technical data on steel and iron analysis through the use of both the Universal and Junior Coleman spectrophotometers are presented by the Wilkens-Anderson Co. in an 8-page, illustrated bulletin. (47)

Melting, Casting, Molding

Cast Iron Melting Pots and Goosenecks. A variety of Refax cast iron melting pots for aluminum and lead, and goosenecks for aluminum, zinc, etc. pressure die casting are described and illustrated in a 4-page bulletin, No. 201-B, published by the American Car & Foundry Co. Complete specifications are included. (48)

Die Casting Machine. This 2-page, illustrated bulletin announces the new Model 200 universal high-pressure hydraulic die casting machine that has 27- by 27-in. die plates, produced by the Cleveland Automatic Machine Co. Complete specifications are included. (49)

Die Casting Machines. This 12-page, illustrated bulletin, No. 4805-A, features two types of all-hydraulic die casting machines —Model 150-A, a cold-chamber injection machine for aluminum and magnesium, and Model 150-Z, a submerged plunger injection machine for lower melting point alloys —available from the Hydraulic Press Mfg. Co. Specifications are included. (50)

Lost Wax Process. This 2-page, illustrated folder presents interesting information on precision casting by the lost wax process, offered by I. Shor, suppliers of materials, equipment and information on all phases of this process. (51)

General

Precision Gears, Couplings, Etc. A complete line of precision gears, Steelflex and Airflex couplings, speed reducers, high-speed drive, etc. produced by the Falk Corp. are described and illustrated in this 12-page bulletin, No. 10,000. (52)

Nitrogen Generator. The development of a new low-cost, self-contained nitrogen generator known as the "Hi-Nitrogen Generator" for use in the metallurgical, chemical, refining, processing and storage industries is announced by Gas Atmospheres, Inc. in a 4-page, illustrated bulletin, No. HN 101. (53)

Permanent Magnets. The positive removal of tramp iron and steel in processing metals, minerals, chemicals, plastics, textiles, etc. through the use of either hinged or hingeless type permanent magnets is discussed by the Homer Manufacturing Co., Inc. in their 6-page, illustrated folder. (54)

Carburetors, Generators, Etc. Complete data on industrial carburetors, nitrogen carburetors, inert-gas producers, dynamic dryers, etc. are presented by the C. M. Kemp Manufacturing Co. in their 12-page, illustrated bulletin, No. 14. Specifications are included. (55)

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I should like a copy of each piece of Manufacturers' Literature specified by number circled below. ***We request students to send their inquiries to the manufacturers***

1	2	3	4	5	6	7	8	9	10	11	12	13	14
15	16	17	18	19	20	21	22	23	24	25	26	27	28
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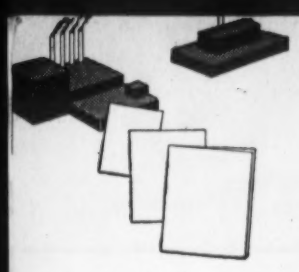
PLEASE PRINT

(February 1948)



MANUFACTURERS' LITERATURE

LITERATURE RECENTLY REVIEWED IN THIS DEPARTMENT

Nontoxic Coating. Acryvin Corp. of America. (56)

Hydraulic Presses. Air Hydraulics, Inc. (57)

Fuel Gas for Welding and Cutting. Air Reduction Sales Co. (58)

Special Steels in Motion Pictures. Allegheny Ludlum Steel Corp. (59)

Oil Circuit Breakers. Allis-Chalmers Manufacturing Co. (60)

Magnesium Alloys. Aluminum Co. of America. (61)

Metal Cleaner and Conditioner. American Chemical Paint Co. (62)

Steel-Base Coils. American Nickeloid Co. (63)

Corrosion Resisting Coating. American Pipe & Construction Co., Amercoat Div. (64)

Welding Brass and Tin Bronzes. Ampco Metal, Inc. (65)

Cutting Stainless and Nonferrous Metals. Arcos Corp. (66)

Creep Stress Data. Babcock & Wilcox Co. (67)

Raised Hub Disk Wheels. Bay State Abrasive Products Co. (68)

Lubricants. Brooks Oil Co. (69)

Blind Rivets. Cherry Rivet Co. (70)

Grinding Machines. Cincinnati Grinders, Inc. (71)

Molded Plastics. Consolidated Molded Products Corp. (72)

Potassium High-Speed Copper Plating. du Pont de Nemours & Co., Inc., E. I.; Electrochemicals Dept. (73)

Quartz Spectrograph. Gaertner Scientific Corp. (74)

Arc Welding Accessories. General Electric Co. (75)

Laminated Metals. General Plate Div., Metals & Controls Corp. (76)

Rubber Mallets. Goodrich Co.; B. F. (77)

Induction Heating. Gordon Electronics, Inc. (78)

Silver Brazing Alloys. Handy & Harman. (79)

Gas Carburizing Furnaces. Holcroft & Co. (80)

Protective Coating. R. M. Hollingshead Corp. (81)

Bronze Bearings. Johnson Bronze Co. (82)

Steel Wire. Johnson Steel & Wire Co. (83)

Boring Tools. Kaukauna Machine Corp. (84)

Cemented Carbides. Kennametal, Inc. (85)

Temperature Regulators. Leslie Co. (86)

Laminated and Solid Precious Metals. Makepeace Co.; D. E. (87)

Carbide Metal. Metal Carbides Corp. (88)

Arc Welding Accessories. Metal & Thermit Corp. (89)

Automatic Chucking Machines. New Britain-Gridley Machine Div., New Britain Machine Co. (90)

Metal Powders. New Jersey Zinc Co. (91)

Abrasive. Norton Co. (92)

Resin Coating. Nukem Products Corp. (93)

Torsion Testing and Wire Twisting Machines. Olsen Testing Machine Co.; Tinius. (94)

Blast Cleaning Equipment. Pangborn Corp. (95)

Inorganic Cleaner. Pennsylvania Salt Manufacturing Co. (96)

Belt Surfacers, Sanders, Etc. Porter-Cable Machine Co. (97)

Protective Coating. Progressive Systems, Inc. (98)

Design-Strengthened Metals. Rigid-Tex Corp. (99)

Hydraulic Slotters. Rockford Machine Tool Co. (100)

Flame Cut Shapes. Ryerson & Son, Inc.; Joseph T. (101)

Fabricated Metal Baskets, Trays, Etc. Stanwood Corp. (102)

Oil Dilution Calculator. Stuart Oil Co., Ltd.; D. A. (103)

Nickel and Nickel Alloy Tubing. Superior Tube Co. (104)

Plastics. Synthane Corp. (105)

Seamless Tubing. Timken Steel & Tube Div., Timken Roller Bearing Co. (106)

Hole Punching Units. Wales-Strippit Corp. (107)

Coating Crucibles. Western Gold & Platinum Works. (108)

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New Materials and Equipment

Temperature Control Unit for Machine Tool Coolants

Niagara Blower Co., 405 Lexington Ave., New York 17, has produced a coolant temperature control unit for application to New Britain-Gridley automatic screw machines. The new unit increases production by eliminating warm-up operations and subsequent tool adjustments as well as preventing variations in the machine work caused by temperatures rising during operating periods.

When the screw machine is operating, the coolant is kept at a pre-determined temperature by the constant evaporation of moisture on the outside of tubes through which the hot coolant oil is flowing. This method removes 1000 b.t.u. per lb. of water evaporated. When the machine is stopped, a fall in the coolant temperature is prevented by the automatic operation of an electric element, which is also used for pre-heating after a longer shut-down period.

Whether the machine is running at high speed, or stopped, or remains idle over night, the temperature of the coolant is always within 2 or 3 degrees of a predetermined point, effectively preventing harmful contraction or expansion of working parts. The unit can be adapted to all multiple spindle automatics.

This coolant temperature control unit eliminates warm-up operations for screw machines.

Metallic Filler and Sealing Compound

A new sealing compound made up of a metallic filler and a plastic binder has been announced by *National Engineering Products, Inc.*, Commerce & Savings Bldg., Washington 4. It can be used for sealing porous castings or seams in metal duct work. It can also be used as a sealing or filling compound on welded or riveted seams, or as a sealant and coating material.

The material, called Plastic Metal 22, has a putty-like consistency and can be applied with a trowel, spatula or caulking gun. It solidifies through solvent evaporation at room temperature. Thin sections reach maximum hardness in 4 hr.; thick sections continue to increase in adhesion, toughness and hardness over a 96-hr. period.

This material is said to have good adhesion with all common metals and retains its properties from 220 F to –65 F. When fully dried, it can be sanded, buffed and cut with wood working tools.

As for chemical resistance, it is unaffected by alcohol, gasoline, oil, water, saturated salt solution, carbon tetrachloride, concentrated phosphoric acid, and 10% solutions of nitric, sulfuric, muriatic, and hydrochloric acids. In addition, the material is reported to be highly resistant to weathering and will not support combustion in its fully dried state.

New Photoelastic Resin Aids Stress Study

A special process developed by *Westinghouse Electric Corp.,* Pittsburgh 30, permits large sections of a photoelastic resin of the Fosterite family to be cast for three-dimensional studies of "frozen stresses." One piece measures 6 in. in dia. and 3 ft. long, and it is believed that sizes and shapes suitable for any kind of three-dimensional study can be produced. In the past plastic models made of ordinary photoelastic resins have been limited to pieces 1⅛ in. thick.

The new resin is 35% more optically sensitive for "frozen stress" measurements than the standard material, and does not fade in usefulness with time. It is used for precision studies a month after machining.

Photoelastic resins in actual use are made up into models, as, for example, a crane hook. After being heated, the model is loaded, and then cooled gradually to room temperature. When viewed through polarized light, the plastic replica shows the location, direction and magnitude of stresses.

Production of a model now takes about one month. Resin is poured into an evacuated glass mold which is then sealed and placed in a water bath. The temperature is then raised to 100 F. Subsequently, the Fosterite is baked in an oven. Slow curing makes the resin essentially free of stresses.

The new resin is still in the experimental stage and is not yet available commercially.

The size of models possible with the new photoelastic resin (left) as compared to a standard resin sample (right).

Low Cost Dew Point Indicator

To meet a growing need in industrial and research fields for a simple device for measuring the moisture content of air and gases at approximately atmospheric pressure, *Pittsburgh Lectrodryer Corp.,* P. O. Box 1766, Pittsburgh 30, is now manufacturing a dewpoint apparatus.

It is claimed that this device is less likely to result in error than the wet and dry bulb method of moisture determination. The apparatus consists of an outer container with inlet and outlet connections and a glass window, an inner container having a highly polished outer surface visible through the window, and thermometer.

To determine the dewpoint temperature a small sample of the gas to be tested is passed through the outer container while a mixture of crushed dry ice and acetone is stirred in the inner container. The stirring is done with the thermometer. As the temperature drops as a result of the stirring, the polished surface of the inner compartment is closely observed through the glass window. At the first indication of dew or moisture on the polished surface of the inner container, the temperature is read from the thermometer. This dewpoint temperature is a reasonable accurate indication of the moisture content of the gas or air under test.

Use of the acetone and dry ice mixture makes possible the quick checking of dewpoints as low as minus 95 F.

Horizontal Drilling and Tapping Machine Is Portable

A new portable horizontal drilling and tapping machine, with a tilting horizontal head for an unlimited number of drilling and tapping operations, is being produced by the *Kaukauna Machine Corp.,* Kaukauna, Wis. Full three-dimensional power traverse and swiveling of the headstock make it practical to perform drilling and tapping operations throughout the range of 45 deg., above or below the horizontal spindle position.

The machine spindle can be placed in virtually any position for drilling and tapping through (1) the power elevation of headstock on column; (2) the column and sub-base power traverse on the runway; (3) the tilting of the headstock 45 deg., above and below the horizontal; and (4) the rotation of the column 360 deg. on its sub-base.

Other features of this unit include fine feed to spindle through micrometer handwheel; adjustable calibrated depth gage with automatic trip throws out feed at any predetermined depth within 6 in. of spindle travel, the starting point being anywhere within the total spindle traverse; single lever control for three feeds; rotary selector lever with indicating dial for speed changes; automatic tapping device with adjustable dial for tapping to a depth of 5 in.; and selector switch for either right or left spindle rotation.

The machine has a capacity of 3 in. in cast iron with a 3-in. dia. spindle, 9 spindle speeds, 3 spindle feeds, and a 24-in. longitudinal continuous travel of spindle and a 48-in. horizontal travel of column on runway.

MAKE A TON OF SHEET STEEL GO FARTHER
Specify—
N·A·X
HIGH-TENSILE STEEL
HIGH STRENGTH
FINER GRAIN STRUCTURE
GOOD FORMABILITY
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GREAT IMPACT-TOUGHNESS
EXCELLENT WELDABILITY
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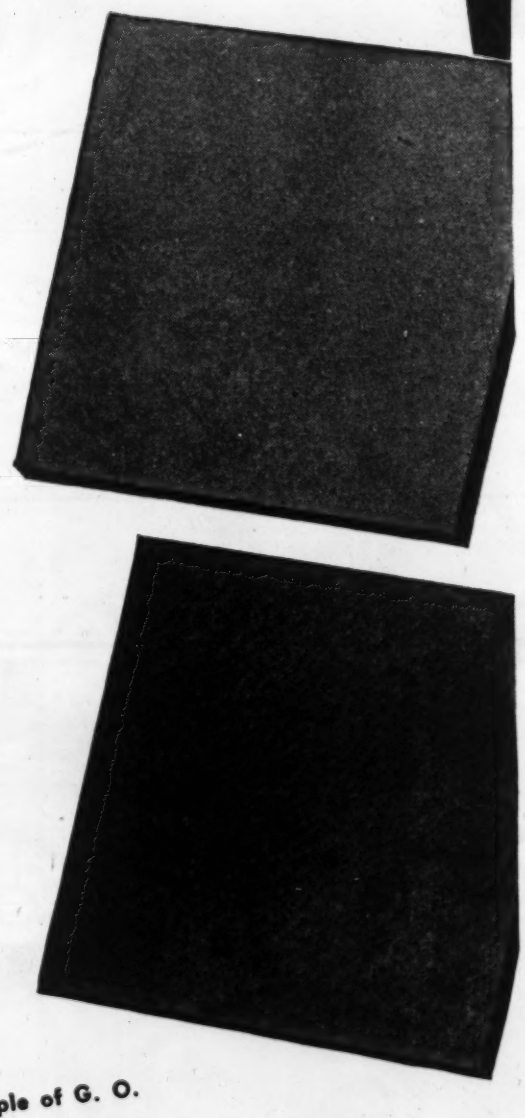
STAINLESS PLATES
WITH NEW
Super Finish
AT NO ADDED COST . . .

Sodium Hydride Descaling and Pickling makes the difference! Stainless Plates and heads from G. O. Carlson, Inc. are delivered to you smooth, clean, and scale-free. No metal is lost; the surface is not penetrated or attacked; original dimensional tolerances are retained.

Compare the "ordinary" finish below with the Carlson Sodium Hydride Finish above. (Unretouched 2" squares.)



See for yourself.

We will be glad to send you a sample of G. O. Carlson, Inc. plate with the new finish—please specify which gauge you prefer—from 3/16" to 1" thick. No obligation.

G. O. CARLSON, INC.
Stainless Steels Exclusively
200 MARSHALTON ROAD, THORNDALE, PA.

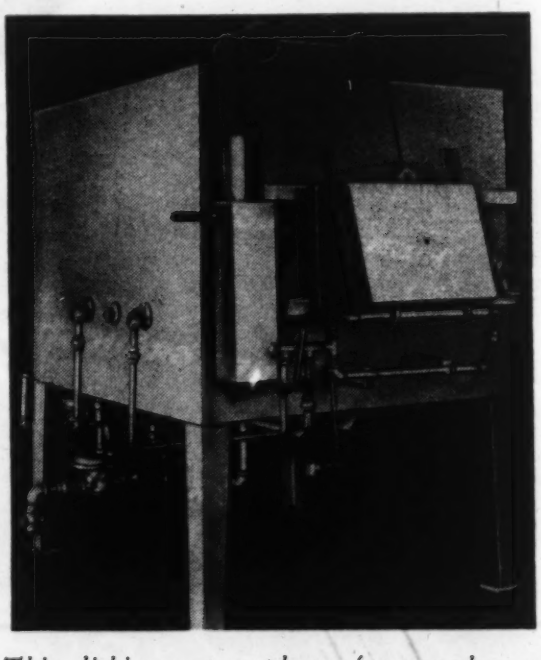
New Lithium Atmosphere Furnace Provides Close Control

A lithium atmosphere universal batch furnace has been developed by the *Lithium Co.*, 111 Sylvan Ave., Newark 4, N. J. The furnace is designed to require no manual control or supervision. By introducing lithium vapor with the usual carrier gas into the heating chamber of the furnace, control of the atmosphere is affected right at the work. The protection of the lithium vapor extends to the instant of quenching or during air cooling, so that there can be no oxidation or change in surface analysis of the metal.

The heat treatment afforded in a lithium atmosphere frequently eliminates after cleaning and even machining. The cost of the lithium used in this furnace would be at the rate of only 2¢ per hr.

This lithium atmosphere furnace is suitable for heating in a temperature range from 1200 to 2100 F. It can be used in neutral annealing, normalizing, hardening, spheroidizing, carburizing, carbon restoration and brazing. It is built for easy batch loading and regulation of heat input and atmosphere.

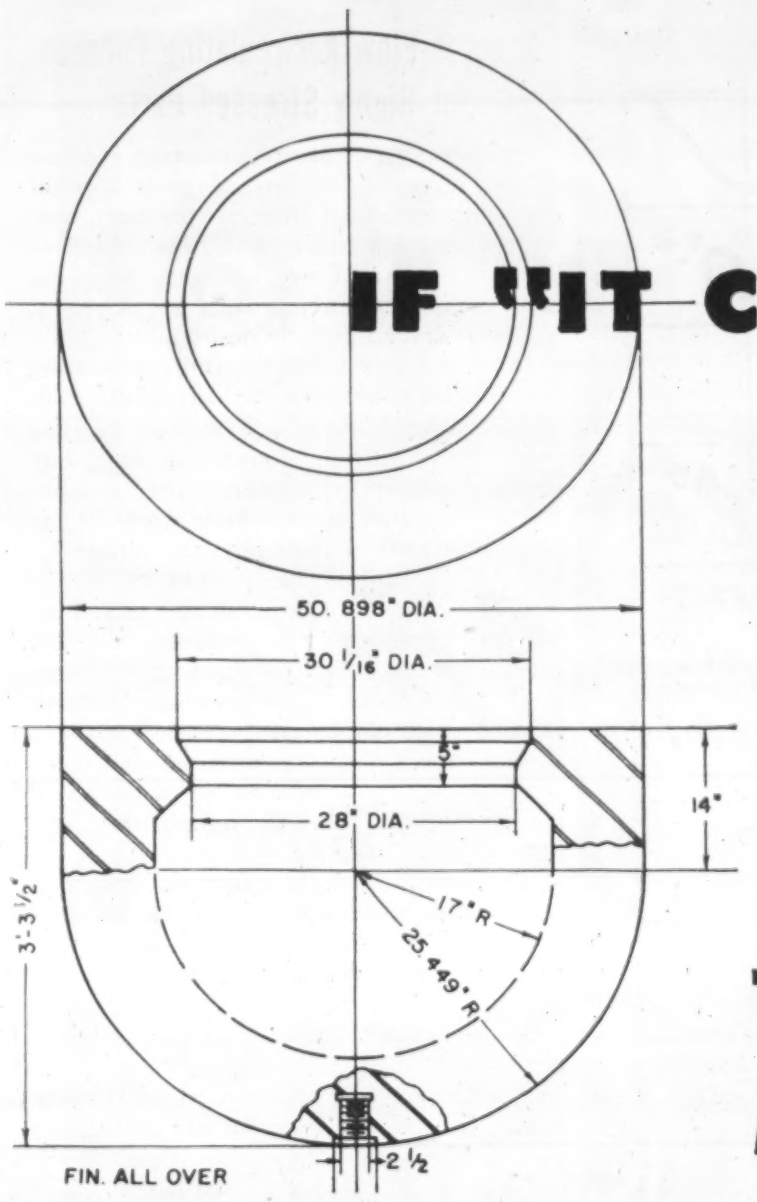
For direct quenching without exposure of the work, the furnace is equipped with a self-discharging, flexible alloy belt or automatic dump trays for loading and discharging of parts. By pulling a rod, the work pieces drop through a sealed chute into a removable basket in the quench tank where



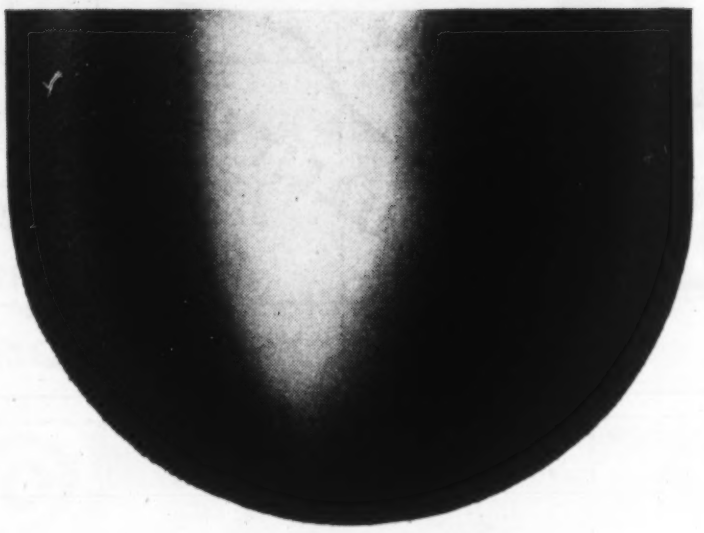
This lithium atmosphere furnace has a flexible belt for automatic loading and discharging of parts.

the quenching medium is circulated by a propeller agitator. Manually operated bridge arms build into the chute permit removal of work without quenching, if desired.

Built into the furnace at the rear is the lithium vaporizer, which is heated separately. Here the lithium cartridge is loaded into the vaporizer chamber through a tube to which is connected the pipe from the carrier gas atmosphere generator. The vaporized lithium and the carrier gas flow through a slotted tube to fill the work muffle.



IF "IT CAN'T BE DONE"



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American Brake Shoe Co.	Mahwah, New Jersey
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Atlas Foundry Co.	Detroit, Michigan
Banner Iron Works	St. Louis, Missouri
Barnett Foundry & Machine Co.	Irvington, New Jersey
E. W. Bliss Co.	Hastings, Mich. and Toledo, O.
Builders Iron Foundry Inc.	Providence, R. I.
H. W. Butterworth & Sons Co.	Bethayres, Pennsylvania
Continental Gin Co.	Birmingham, Alabama
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co.	Portland, Oregon
Farrel-Birmingham Co., Inc.	Ansonia, Connecticut
Florence Pipe Foundry & Machine Co.	Florence, New Jersey
Fulton Foundry & Machine Co., Inc.	Cleveland, Ohio
General Foundry & Manufacturing Co.	Flint, Michigan
Greenlee Foundry Co.	Chicago, Illinois
The Hamilton Foundry & Machine Co.	Hamilton, Ohio
Johnstone Foundries, Inc.	Grove City, Pennsylvania
Kanawha Manufacturing Co.	Charleston, West Virginia
Koehring Co.	Milwaukee, Wisconsin
Lincoln Foundry Corp.	Los Angeles, California
The Henry Perkins Co.	Bridgewater, Massachusetts
Pohlman Foundry Co., Inc.	Buffalo, New York
Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
Ross-Meehan Foundries	Chattanooga, Tennessee
Shenango-Penn Mold Co.	Dover, Ohio
Standard Foundry Co.	Worcester, Massachusetts
The Stearns-Roger Manufacturing Co.	Denver, Colorado
Traylor Engineering & Mfg. Co.	Allentown, Pennsylvania
Valley Iron Works, Inc.	St. Paul, Minnesota
Vulcan Foundry Co.	Oakland, California
Warren Foundry & Pipe Corporation	Phillipsburg, New Jersey
Washington Machinery & Supply Co.	Spokane, Washington
E. Long Ltd.	Orillia, Ontario
Otis-Fensom Elevator Co., Ltd.	Hamilton, Ontario

"This advertisement sponsored by foundries listed above."

THE MEEHANITE DIE shown is regularly performing a single pressing operation about which it had been said "it can't be done." Its function is to cold press 5/16" steel plate into half-ball shapes. These forms are welded together to produce gas storage vessels.

Used in conjunction with Meehanite drawing and clamp rings, the punch is 51" in diameter, 39½" long, and has a metal thickness of 8½". Its weight is about 13,000 lbs. In less than a year's operation the die has been used to produce about 1000 vessels or 2000 pressings.

Meehanite dies for drawing, forming and stamping represent one of the outstanding contributions from a production standpoint, offered by the controlled, dependable, better properties of Meehanite castings. Their engineering characteristics include better tensile properties, a high compressive strength, *real* resistance to wear, and heat-treatability —all a result of metallurgical controls which provide a tough pearlitic matrix evenly dispersed with graphite flakes.

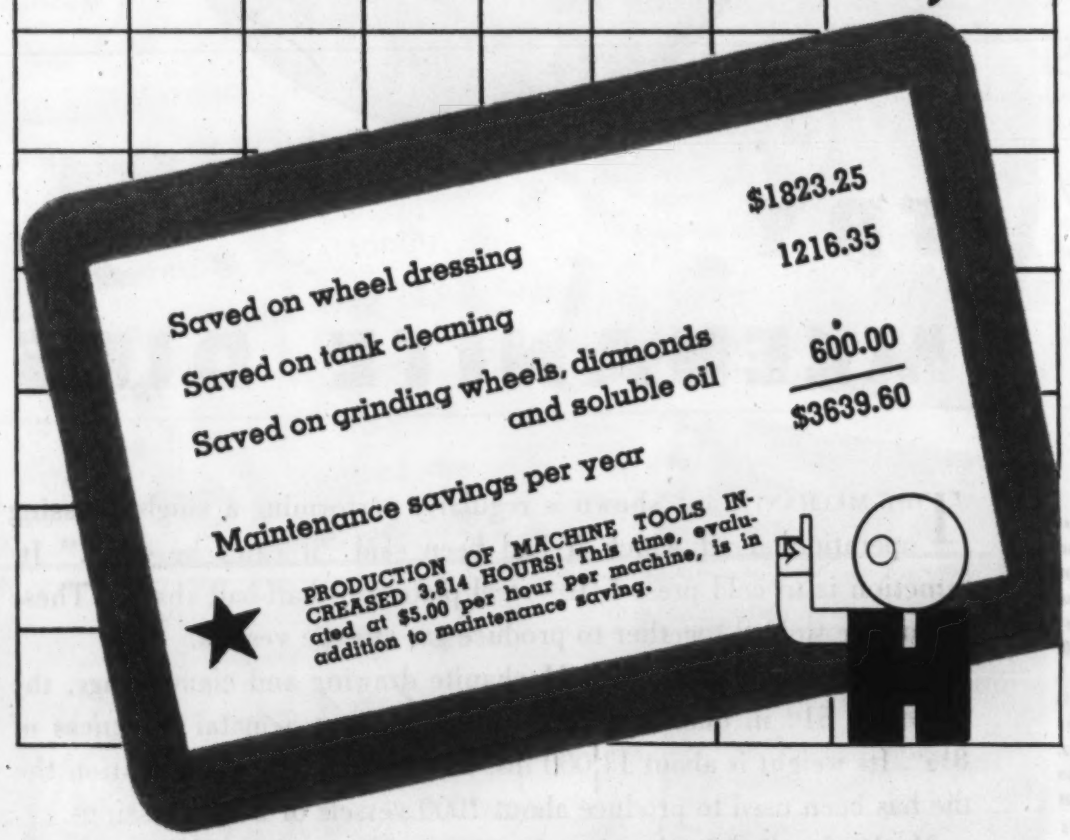
In other fields including those of heat and abrasion resistance as well as in those general engineering jobs where better quality is required, Meehanite castings have frequently been the answer when it was thought that—"it can't be done."

For further details about Meehanite dies write for our bulletin entitled "Meehanite—an 'All-Around' Die Material."

MEEHANITE®

PERSHING SQUARE BUILDING • NEW ROCHELLE, N. Y.

UP WENT THE RATE AND QUALITY OF PRODUCTION AS HOFFMAN FLOTATION EQUIPMENT PROVED: "IT PAYS ITS WAY" IN *Savings!*

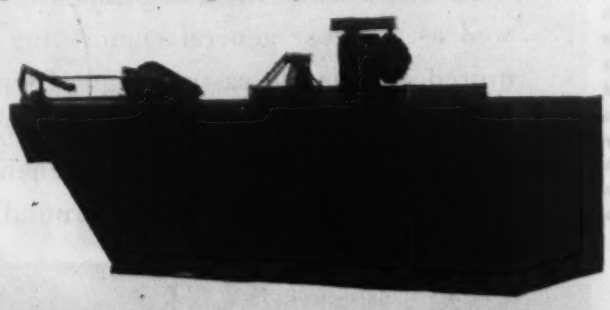

Saved on wheel dressing $1823.25
Saved on tank cleaning 1216.35
Saved on grinding wheels, diamonds and soluble oil 600.00
$3639.60
Maintenance savings per year
PRODUCTION OF MACHINE TOOLS INCREASED 3,814 HOURS! This time, evaluated at $5.00 per hour per machine, is in addition to maintenance saving.

Above are significant figures from an actual plant test made recently with Hoffman Flotation equipment. They prove that better and faster machining can be yours at no extra cost! While the Hoffman equipment cuts "down" time, builds quality control and lengthens tool life, it also ACTUALLY PAYS FOR ITSELF in maintenance savings!

You will note that production time is *NOT included in the test saving figure above.* An additional $19,000 was saved by the Hoffman flotation units. Grinders were operated continuously — no "time-out" was needed for cleaning sumps—wheel dressing time was cut. The Hoffman flotation unit delivered clear coolant *automatically.*

Hoffman flotation units *aerate out* solid impurities by a new principle. No filters to change—no strainers to clean . . . entirely mechanical with no added material. For all the money-saving facts, write now.

Completely Automatic HOFFMAN UNITS for Coolant Clarification
Write for details



U. S. HOFFMAN MACHINERY CORPORATION
223 Lamson St., Syracuse, N. Y.
COOLANT FILTERS • FILTRATION ENGINEERING SERVICE

Reverse-Flow Recirculating Furnace for Highly Stressed Parts

A new type of recirculating furnace which reverses the flow of gases through the work at regular intervals has been built by *Sunbeam-Stewart Industrial Furnace*, Div. of *Sunbeam Corp.*, Chicago. An exclusive damper arrangement is employed to give any reversing cycle desired.

This new unit has application in industry for the heat treatment of any high stress parts. Among these are aircraft landing gears, valve springs, connecting rods, cam shafts, coil springs, martensitic stainless steels and other parts where work has to be heat treated to close physical limits.

Work is said to be brought up to the desired temperature faster in this recirculating furnace than in a conventional one, and the final temperature variation through the work is small. In addition, where speed of heating is limited by temperature variations through the work, it is reported that heating rates are increased because of the small temperature variation throughout the heating cycle.

The reversing cycle timer is adjustable from 30 sec. to 5 min. The fan has a capacity of 4800 C.F.M. @ 3 in. S.P. It is made of cast, heat resisting alloys. The door lift may be air or hydraulic, hand or foot valve, or electric switch. Maximum temperature is 1250 F.

The furnace is available in the following basket sizes: 24 in. by 30 in.; 30 in. by 36 in.; 36 in. by 36 in.; and 36 in. by 48 in., heated gas, oil or electrically.

New Furnace for Continuous Tempering Up to 1650 F

A new series of furnaces capable of operating continuously at 1650 F has been announced by *Leeds & Northrup Co.*, 4934 Stenton Ave., Philadelphia 44. High-temperature stress relief, cycle annealing, spheroidizing, normalizing and similar heat-treatments of ferrous and nonferrous parts are typical operations. Lower-temperature work can be handled in the same furnace with equal efficiency.

One feature of the furnaces is a ribbon-type heater of the heavy variety. Fan motors are also provided that have a water-cooled gland to protect against overheating.

These furnaces are said to be capable of handling big, dense loads on a mass production basis. Capacities vary from 1.8 cu. ft., (15 in. dia. by 18 in. deep), to 33.4 cu. ft., (35 in. dia. by 60 in. deep). They have forced-convection heating to bring loads quickly to soak and provide uniform temperature throughout the load. Operating costs are reported low, because of the large load capacity, fast heating and uninterrupted operation.

A BUYING GUIDE FOR ABRASIVES

ABRASIVE PROBLEM:

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CARBORUNDUM
TRADE MARK

The Carborundum Company has developed an entirely new and more convenient method of packaging coated abrasives. Based on a careful analysis of requirements and problems of both users and distributors, it facilitates use, handling, shipping and stocking of coated abrasives.

Under this new system, sturdy packages contain "decimal" quantities of 25, 50 or 100 sheets. Cartons replace paper wrappings. Standard units are emphasized. Products are clearly identified by their end-use name on labels and backing. Ordering is expedited. Pricing and inventory are simplified. Handling is easier. Cardboard sleeves protect against curling and tearing.

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BONDED ABRASIVES

COATED ABRASIVES

ABRASIVE GRAINS AND FINISHING COMPOUNDS

Specialized wheels by CARBORUNDUM for thread grinding
Diamond wheels to meet stiffer technical needs
Cool-cutting green grit wheels for cemented carbide
A coated abrasive for every grading and finishing condition
All standard shapes are supplied in grinding wheels by CARBORUNDUM

"Carborundum" is a registered trade mark which indicates manufacture by The Carborundum Company

BARRETT ANHYDROUS AMMONIA

...andard Source of NH_3 ...r Metallurgical Uses

- NITRIDING STEELS
- BRIGHT ANNEALING
- ATOMIC WELDING AND BRAZING
- CONTROLLED ATMOSPHERES
- POWDER METALLURGY SINTERING ATMOSPHERE
- REDUCTION OF METALLIC OXIDES

THESE are a few of the many metallurgical uses for Barrett Anhydrous Ammonia—minimum purity 99.95% NH_3 . . . oxygen free . . . very low dew point. Consistent purity, uniform dryness, speedy deliveries and dependable service have made Barrett Anhydrous Ammonia the *standard* of quality.

Because it is shipped as a concentrated liquid and can be dissociated into its component gases at points of use, Barrett Anhydrous Ammonia is an economical source of nitrogen and hydrogen. When dissociated, each pound of Barrett Anhydrous Ammonia produces approximately 11 cubic feet of nitrogen and 34 cubic feet of hydrogen.

Barrett Anhydrous Ammonia is available in 50, 100 and 150-pound cylinders from warehouses conveniently located from coast to coast; or, for larger users, in tank car shipments from Hopewell, Virginia, and South Point, Ohio. It must pass rigid tests for moisture, non-condensable gases and other impurities before release for shipment. Cylinders and tank cars are thoroughly cleaned and inspected, upon return to the plant, before reloading.

The advice and help of Barrett technical service men are available to Barrett customers without charge. Free literature on Barrett Anhydrous Ammonia will be mailed on request.

THE BARRETT DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 RECTOR STREET, NEW YORK 6, N. Y.

Barrett

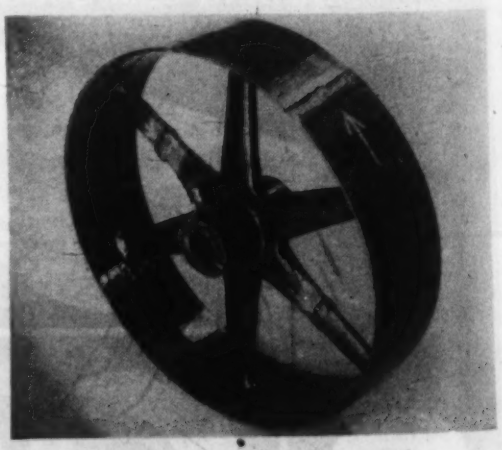
New Welding Electrodes and Rods

A new electrode, Hobart Softcast A, announced by the *Hobart Brothers Co.*, Hobart Square, Troy, Ohio, is a copper-nickel alloy having a mineral flux coating for metallic arc welding. The weld deposits are non-ferrous, light grey in color, malleable, easily machinable and have a tensile strength equal to good cast iron. It is especially adapted to the welding of cast iron where the weld area must be machined, drilled or tapped anywhere in the weld zone. These electrodes are available in 3/32-in., ⅛-in., 5/32-in. dia. in 18-in. lengths, center brushed, and can be used on a.c. or d.c. current.

A new hydrogen free, mineral type, extrusion coated electrode that is said to eliminate underbead cracking is available from *Westinghouse Electric Corp.*, Pittsburgh 30. Ranging in diameters from ¼ in. to ⅛ in., these electrodes are recommended for use with direct-current reverse polarity and also for alternating current. Typical of the applications of this electrode are welding high carbon steels, high carbon to low alloy steel, low alloy steels, high sulfur bearing steels not heretofore weldable, welding mild steel structures that are to be vitreous enameled without previous heat treating, and steel parts of unknown analysis.

The *Lincoln Electric Co.*, Cleveland, Ohio, announces a new electrode, Toolweld A & O, for hardsurfacing tools and dies. It can be used in building up the working surfaces or edges of cold-working metal cutting and forming tools. It will produce surfaces of high strength for resisting wear and impact in all applications where high temperatures are not encountered. The deposited weld metal is of the 5% chromium type and can either be used as welded or subjected to a wide range of heat treatment to give the maximum hardness quality in the weld. When used on tool steel, the weldment can be heat treated as is demanded by the nature of the base material.

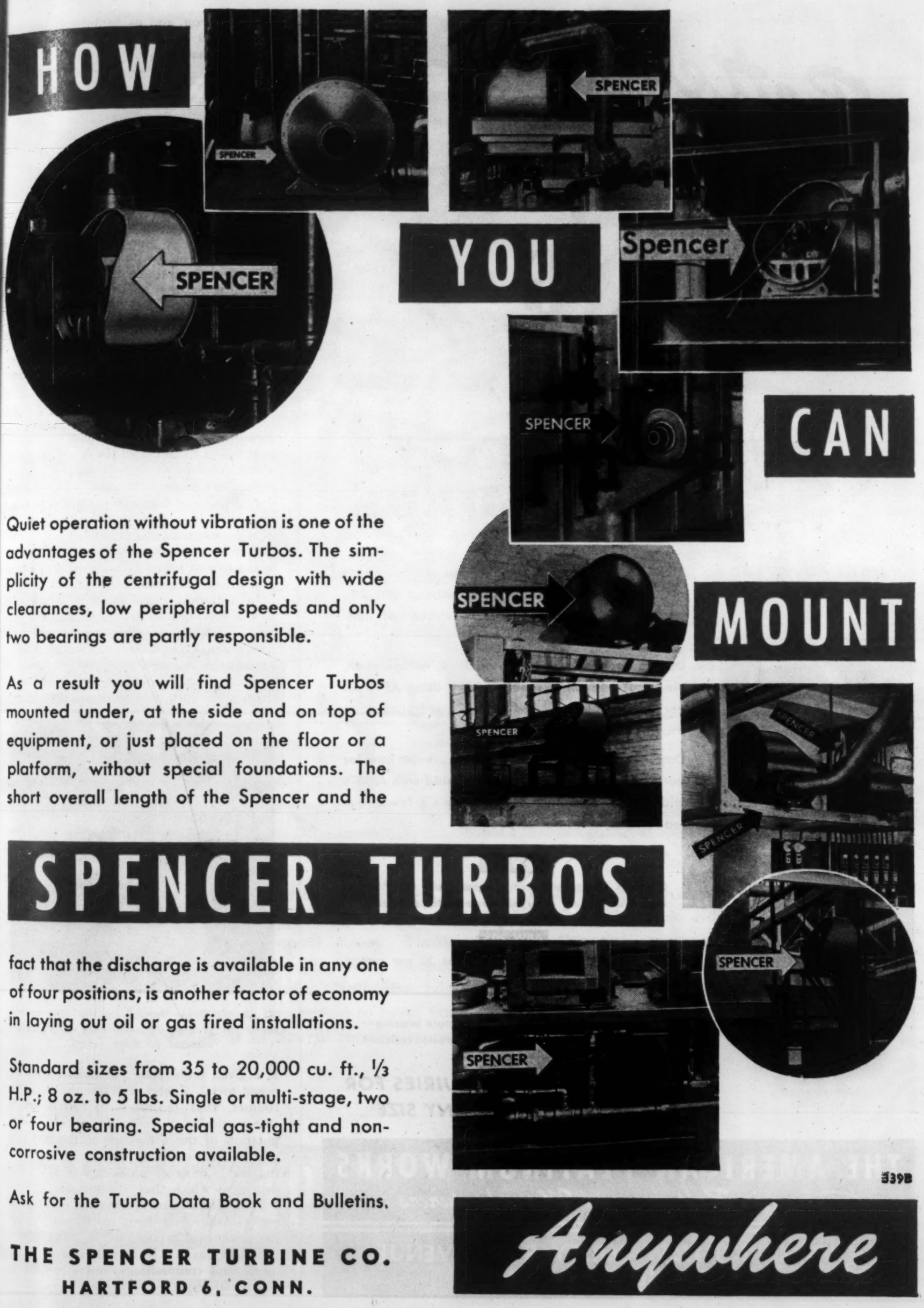
Designed specifically for all types of gray or alloy cast iron, a new color-matching



Cast iron pulley 16 in. in dia., welded with new flux-coated gas rod for cast iron.

flux-coated torch welding rod, known as EutecRod 14 FC, has been announced by *Eutectic Welding Alloys Corp.*, 40 Worth St., New York 13. This rod develops a tensile strength of 48,000 psi. in the weld deposits, bonding at 950 to 1400 F, with a remelt temperature of 2200 F. Its coefficient of expansion is the same as that of

HOW YOU CAN MOUNT SPENCER TURBOS Anywhere



Quiet operation without vibration is one of the advantages of the Spencer Turbos. The simplicity of the centrifugal design with wide clearances, low peripheral speeds and only two bearings are partly responsible.

As a result you will find Spencer Turbos mounted under, at the side and on top of equipment, or just placed on the floor or a platform, without special foundations. The short overall length of the Spencer and the fact that the discharge is available in any one of four positions, is another factor of economy in laying out oil or gas fired installations.

Standard sizes from 35 to 20,000 cu. ft., 1/3 H.P.; 8 oz. to 5 lbs. Single or multi-stage, two or four bearing. Special gas-tight and non-corrosive construction available.

Ask for the Turbo Data Book and Bulletins.

THE SPENCER TURBINE CO.
HARTFORD 6, CONN.

B39B

MANY FORMS FOR YOUR CONVENIENCE

We've had years of experience in developing and manufacturing low temperature brazing alloys to produce strong, sound joints on ferrous and non-ferrous metals.

Day in and day out the automotive, refrigeration, electrical and other industries are using APW silver brazing alloys...and getting good production records, too.

Don't wait for the next requisition...write now for our folder No. 45 and get acquainted with APW's wide range of brazing alloys. Here's a few of our leaders that will interest you:

APW 217

Contains 45 per cent silver. Exceptionally fast flowing. Our leading alloy for large-scale production.

APW 205

Low in cost—high in strength—has 35 per cent silver content.

APW 355

A premium alloy for lowest temperature brazing—cadmium-free—highly ductile and corrosion resistant.

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THE AMERICAN PLATINUM WORKS

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PRECIOUS METALS SINCE 1875

231 NEW JERSEY R. R. AVENUE
NEWARK 5, N. J.

gray cast iron, and its hardness is approximately 190 Brinell, producing welds that are fully machinable.

Tester Measures Adherence of Porcelain Enamel

A new testing apparatus for measuring the adherence of porcelain enamel to base metal by means of magnetic counting has been developed at the National Bureau of Standards by the *Research Foundation of the Porcelain Enamel Institute,* 1010 Vermont Ave., N. W., Washington 5. The new instrument was primarily designed to supplement the conventional fracture test for adherence and provide more complete data on the impact characteristics of porcelain enamels.

The tester unit is assembled in one piece, consisting of a test head, stand, and specimen holder mounted on the control cabinet, which contains the power supply, selector switch, and magnetic counter. The test head is molded plastic and contains 169 spring-actuated steel probes, individually connected to respective segments of the selector switch. The mass of probes, similar in appearance to the face of a fine wire brush, is arranged in a hexagonal pattern, 0.10 in. on centers.

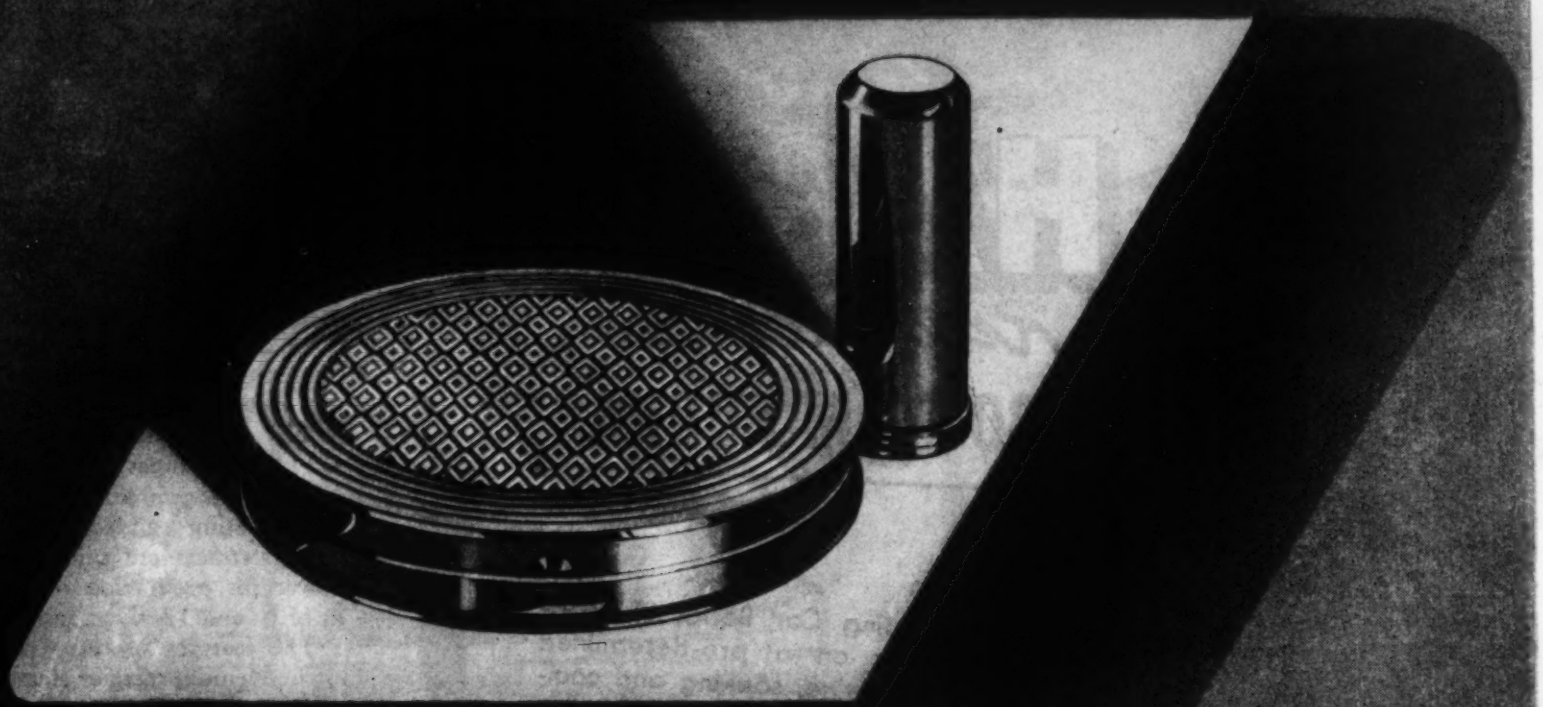
In operation, a ground wire is attached to the specimen to be tested and the test head lowered onto the test surface, the spring-actuated probes adjusting to the contour of the test area. A synchronous motor actuates the selector switch and each circuit, in turn, is automatically tested.

A sample being tested on the new instrument for measuring adherence of porcelain enamel to base metals.

If a given probe comes in contact with exposed metal, a relay activates the magnetic counter, thus recording the attraction of that particular probe to the surface. Computation of the adherence of the test area as a whole is easily carried out by determining the number of probes affected and the degree to which they are affected.

In addition to computing the numbers of probes contacting bare metal, analysis of the patterns of exposed metal indicates how porcelain enamel, in a multitude of thicknesses and compositions, reacts to varying degrees of impact.

AHCO BUFFING COMPOSITIONS ADD BEAUTY TO COSMETIC ITEMS BY



SCOVILL

The Scovill Manufacturing Company, a great name in industry, produces millions of lipstick shells and compact cases. Many are buffed and colored with AHCO Buffing Compounds. Apothecaries Hall chemists formulated a special compound to meet the exacting standards of Scovill for this work.

Hundreds of other manufacturers have benefited from Apothecaries Hall Company policy of "special compounds for special applications." Our research staff and laboratory facilities are always at the service of industry . . . are YOURS for the asking. Why not let us help you?

APOTHECARIES HALL COMPANY · WATERBURY · CONNECTICUT · 1849 · 99TH Year

BOX B

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WATERBURY 88 CONN.

HAGAN
Recirculating
CAR BOTTOM FURNACES

CONTROLLED COOLING

GAS OR OIL FIRED

UNIFORM SOAK

UNIFORM HEATING CYCLE

This Hagan Recirculating Car Bottom Furnace stress-relieves castings on a pre-determined automatic program, heating, soaking and cooling mixed charges weighing up to 40,000 lbs. The complete cycle is accomplished by straight line temperature progression in as little as seven hours. Temperature is automatically controlled within a range from 400° to 1200° F. on either gas or oil. It is also uniformly controlled lengthwise of the furnace and is accurately maintained in charges of miscellaneous castings varying as much as from 20 lbs. to 18,000 lbs. in the same load — as checked at 10 points in the furnace! Fully automatic controls, self-contained car drive and super-duty 1600° fans are typical of the Hagan construction features that assure accurate low cost furnace operation. Let Hagan engineers apply these advanced techniques to your furnace requirements.

GEORGE J. HAGAN CO.
PITTSBURGH, PA.
DETROIT • CHICAGO • LOS ANGELES • SAN FRANCISCO

Two New Selenium Rectifiers for Plating

A new 9-v., 2500-amp. selenium rectifier has been introduced by the *Bart-Messing Corp.*, 45 Morgan Ave., Brooklyn. This unit was primarily designed to permit a reserve of voltage for platers desiring to use diluted solutions of chromic acid or other baths to conserve their limited supplies of critical materials.

It is reported that the quality of plating of a diluted solution has not affected the quality of the work; in fact, has shown an improvement and at a considerable saving in materials. Efficiencies over 72% are claimed at full load and up to 83% at 20% load.

The selenium elements have over 7700 sq. in. of effective rectifying area (approx. 310 sq. in. per 100 amp.), and are triple impregnated for corrosion protection.

A new line of low voltage high current rectifiers is also available from *Mellaphone Electronic Rectifier Co., Inc.,* Rochester 2, N. Y., for operation from 220- or 440-v., three-phase, a.c. power lines. The d.c. output voltage can be varied from 0 to 6 v., with a capacity of 600 amp., or from 0 to 12 v. with a capacity of 300 amp.

Although primarily intended for use in electroplating and electrolytic cleaning, these rectifiers are suitable as a source of power for production testing and running in of 6- and 12-v. d.c. motors, etc.

The features of these new rectifiers include selenium rectifier elements, thoroughly sealed, providing high efficiency; and heavy duty variable voltage transformer, providing stepless control over output voltages, from zero to maximum setting.

New Line of Welders for Shop Use

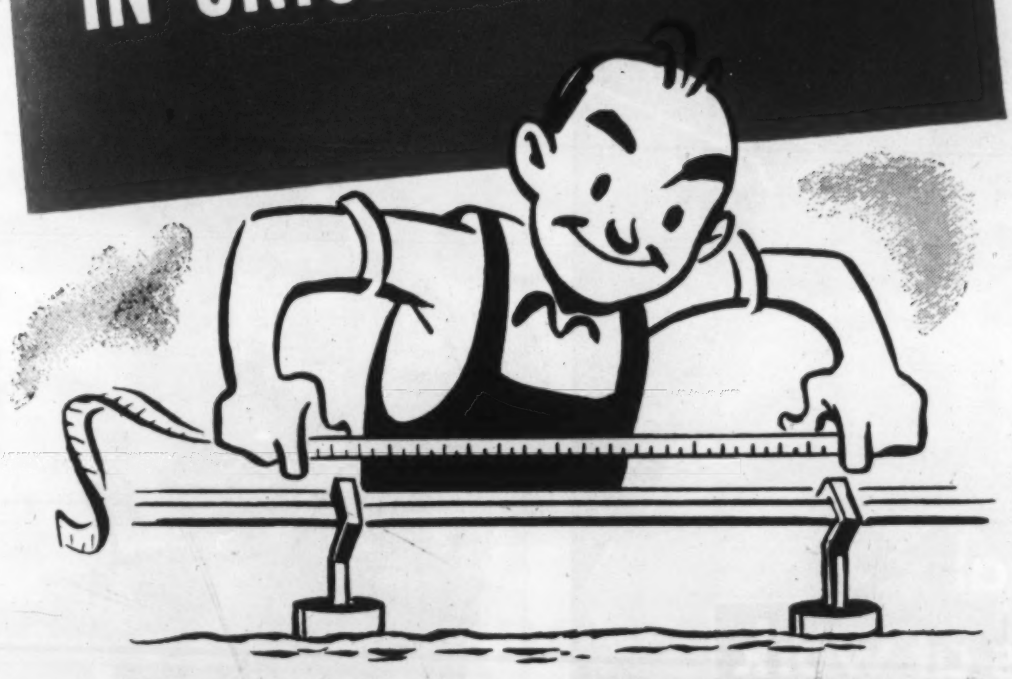
A new line of a.c. welders has been developed by the *John A. Kern Co.*, 224 N. Loomis St., Chicago 7. The line includes three industrial models—200, 300 and 400 amp., and two models for farm and general shop use—130 and 180 amp. All models are NEMA rated.

Among the features claimed by the manufacturer are patented electrical and magnetic circuits which result in an instant starting, smooth and stable arc at all amperage settings; compactness due to the fact that the movable core on all models travels less than 1 in. to cover the entire range of stepless amperage control; the absence of rotary parts results in quiet operation and virtually eliminates the need for lubrication and maintenance; efficient cooling is brought about by providing ample air passages around coils and cores.

The air intake at the bottom of the housing is more than a foot above the floor, thereby eliminating the chances of dust and dirt restricting the air flow.

YOU TIE UP

FEWER ANODES IN UNICHROME COPPER

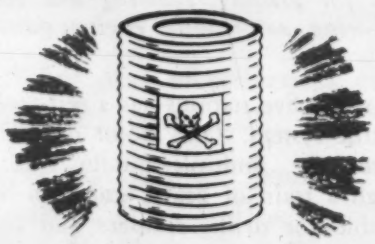


. . . and make sure of 100% anode-efficiency, besides!

IT'S MONEY IN YOUR POCKET instead of copper in your tank when you plate with *Unichrome* Copper. For anodes always corrode evenly—even at high current densities. So you get 100% anode-efficiency—*with 50% to 75% fewer anodes!* And that adds up to plenty of poundage in most installations.

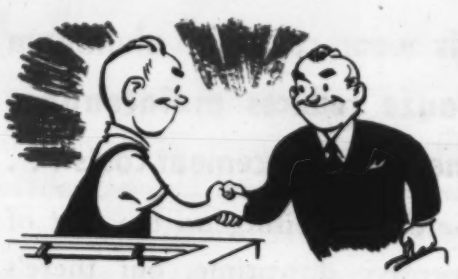
And this is only one of five important advantages you get from the mildly alkaline, all-purpose Unichrome process. Which is why we say: Compare it with any other process, and we believe you'll specify Unichrome Copper every time! *Write for helpful technical bulletin.*

BUFFING TIME IS CUT—often eliminated entirely—because Unichrome Copper gives you a *smoother* deposit. And because it's a *fast* process, you save time in the tank as well. Only when you save *both* ways do you really lower plating costs.



NO CYANIDE is used in the Unichrome Copper bath—so you not only reduce your stocks of this hazardous chemical, but get a safer bath as well.

CLEAN DEPOSITS never need activation. With no brighteners, no wetting agents used, Unichrome deposits come out clean, ready for the nickel cycle without special treatment.



HELPFUL SERVICE—Unichrome Copper is simple to maintain, seldom gives trouble. But should the need arise, you can always count on prompt help from our engineers and analytical laboratories.

UNICHROME

PROCESSES AND MATERIALS

FOR SURFACES THAT SURVIVE

Chromium Plating • Porous Chromium • Unichrome* Copper
Unichrome Lacquers • Ucilon* Protective Coatings
Unichrome Stop-Off Lacquers and Compounds • Unichrome Dips
Unichrome Rack Coatings • Anozinc* Compounds • Unichrome Strip

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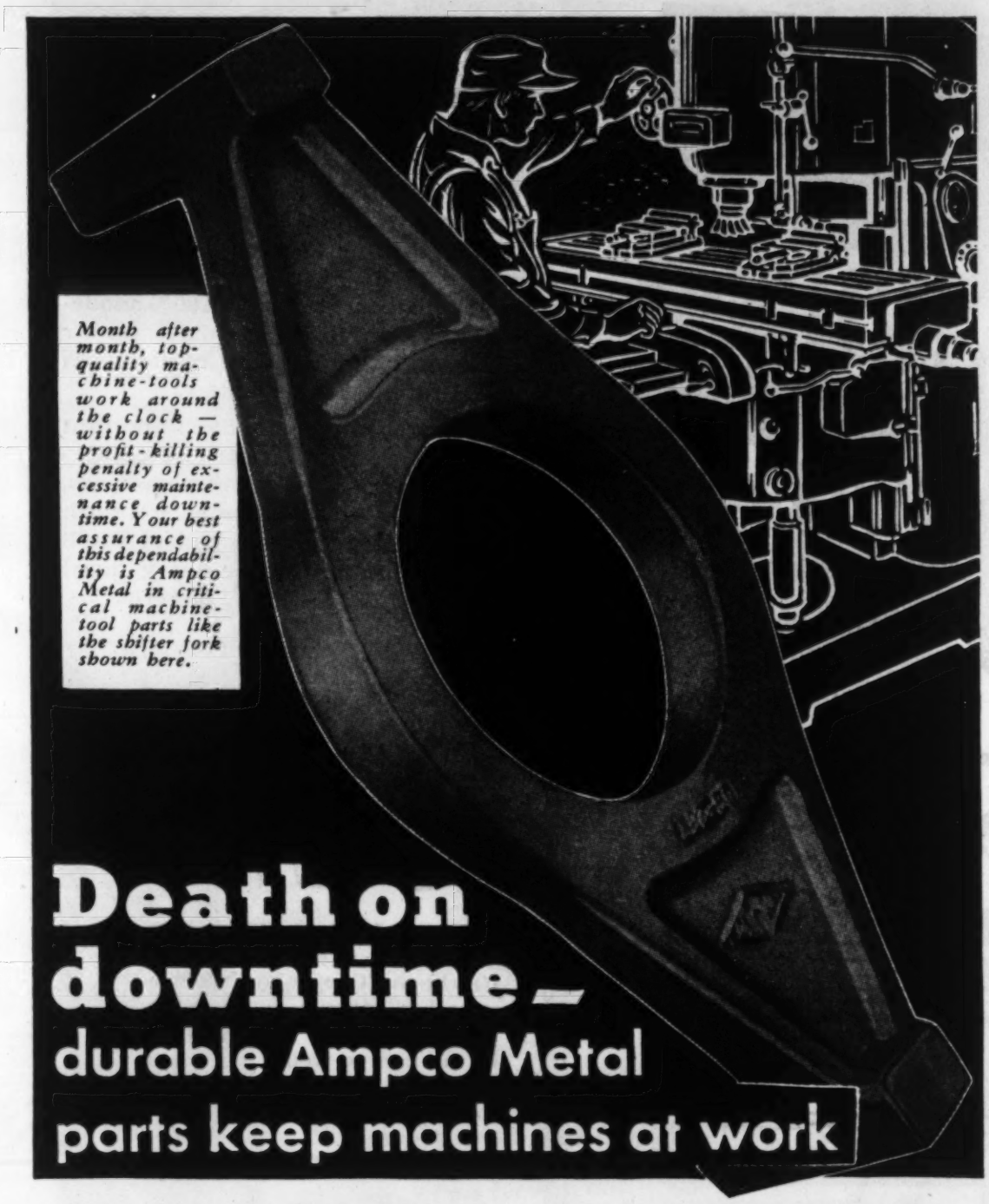
UNITED CHROMIUM, INCORPORATED

51 East 42nd St., New York 17, N. Y. • Detroit 7, Mich. • Waterbury 90, Conn. • Chicago 4, Ill. • Dayton 2, Ohio • Los Angeles 11, Cal



Month after month, top-quality machine-tools work around the clock — without the profit-killing penalty of excessive maintenance downtime. Your best assurance of this dependability is Ampco Metal in critical machine-tool parts like the shifter fork shown here.

Death on downtime—
durable Ampco Metal parts keep machines at work

This wear-resistant aluminum bronze reduces maintenance time and replacement costs . . .

There's no ceiling on the cost of expensive downtime, but there's good insurance against it—durable Ampco Metal in critical machine-tool parts. The extra wear-resistance of this modern aluminum bronze means longer and better service—lower maintenance costs.

Ampco Metal parts are a mark of quality to look for when you buy new equipment. Replace worn parts in your present machines with Ampco Metal to reduce replacement frequency in the future and slash your service and maintenance costs to a new low.

Ampco Metal can be produced by centrifugal- and sand-casting, extrusion, or forging processes according to your requirements. Let your nearby Ampco engineer help you select the proper grade for your needs, from the seven standard grades and several modifications available. For complete information, write for Bulletin 71.

AD-32A

Ampco Metal has 7 outstanding performance advantages

Excellent bearing qualities • High strength-weight ratio • High compressive strength • High impact and fatigue values • Corrosion resistance • Wear resistance • Efficiency at extreme temperatures.

Ampco Metal, Inc.
Dept. MA-2, Milwaukee 4, Wis.
Field Offices in Principal Cities

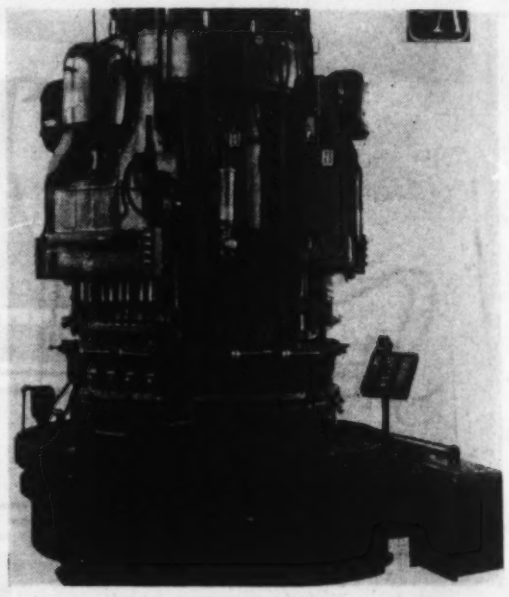
AMPCO
TRADE MARK
REG. U. S. PAT. OFF.

High Production Unit Processes Auto Parts

A new high-production processing machine for drilling, reaming and counterboring automobile engine connecting rods and caps has been developed by the *Sommer & Adams Co.*, Warren, Ohio. The machine, which is over 11 ft. tall and weighs 36,000 lb. produces over 240 drilled, reamed and counterbored assemblies per hr. with a single operator.

The five-station machine is push button controlled, and the spindles are controlled for tool set-up purposes through manual controls on each individual station. The machine, which also has an automatic cycle for continuous operation, is equipped with a motor driven hydraulic unit for indexing and locking the table.

The hydraulic system employs a 5 P.W.X. variable-displacement pump which automatically adjusts itself for proper pressure.



Shown here is the five-station machine designed for drilling, reaming and counterboring automobile engine parts.

Each of the five stations has a self-contained hydraulic system. One motor on each unit operates the multiple-spindle drill head through a train of gears, and each head is adaptable for drills, reamers and counterborers.

The work pieces, which are broached before being brought to the machine, are worked four at a time at each station. Sequence of operations at the various stations is as follows: Station 1 counterbores the cap shoulder; Station 2 drills through the cap and spots the connecting rod (both pieces in position); Station 3, using a drill smaller than that used at Station 1, drills through the connecting rod; Station 4 core drills run through cap and connecting rod, thus lining up pieces and creating a semi-finish in the bores; Station 5 removes the final stock (0.0003 in. to 0.0005 in.), giving a final line-up of the parts and a smooth reamed finish to the bores.

These operations leave the connecting rod and the cap assembly ready for use. Since the fastening bolts, which have a smooth ground surface, are positioned with a light tapped fit snug enough to prevent any play, the bolts act as fasteners and locating dowels.

For Simple and Effective Oven Control

...Use Brown Thermometers!

Simplicity and effectiveness can be combined in an oven control system.

Passing through this oven at Servel, Inc., in Evansville, Indiana, is an endless stream of uniformly heated refrigerator components. Close temperature control is required despite occasional large load changes.

Effective control is provided by a simple Brown Air-o-Line Control Thermometer. The advanced, simple design of Brown Thermometers is the reason for their unparalleled dependability record.

Servel, Inc., is well acquainted with the performance of Brown Thermometers. Several hundred are used on curing ovens, drying ovens and other devices throughout the Servel plant—providing effective measurement and control without an elaborate installation.

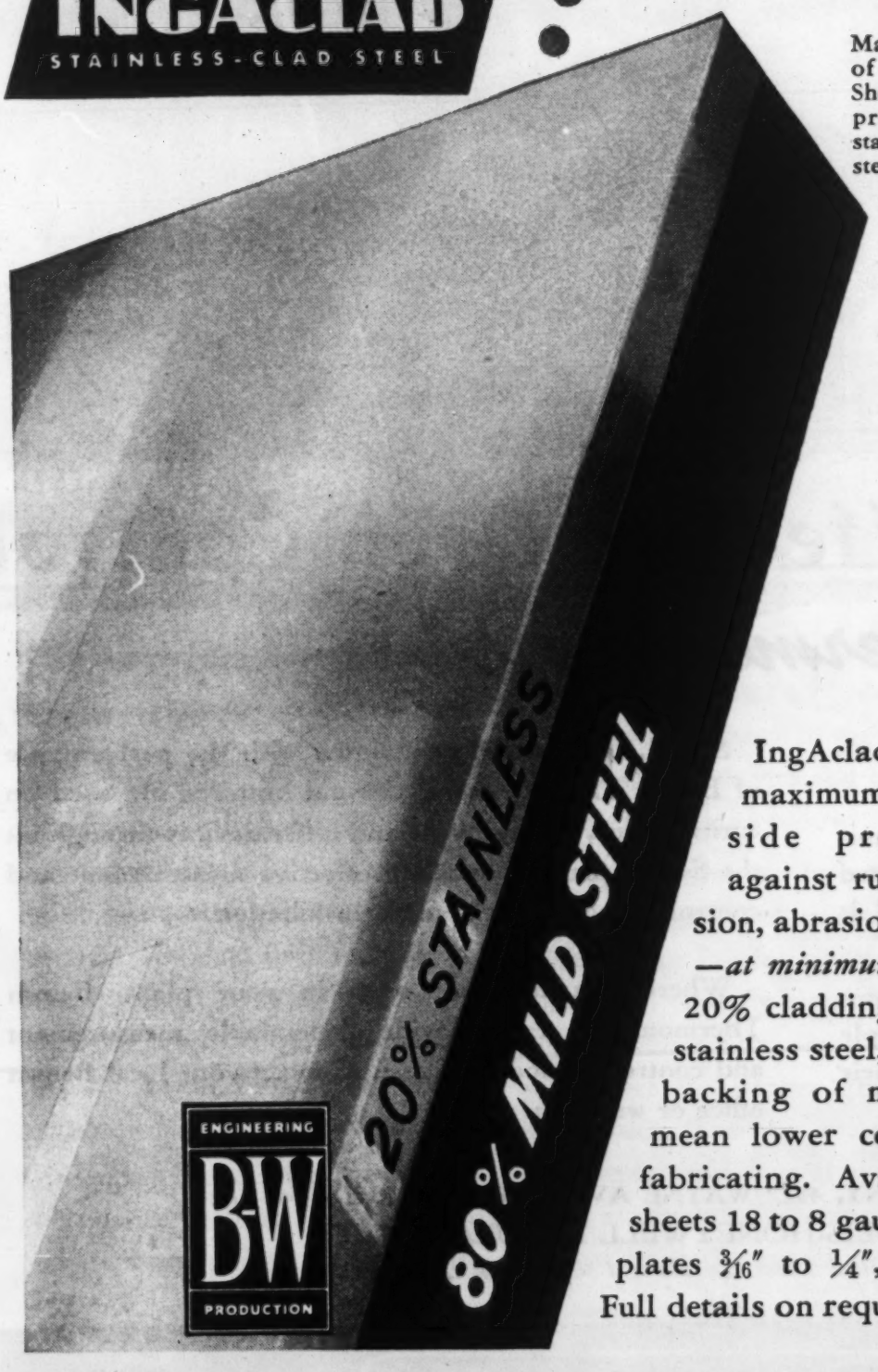
Where you have an oven in your plant, Brown Thermometers can provide dependable measurement and control at moderate cost. Contact your local Brown office or write to:

THE BROWN INSTRUMENT COMPANY, 4517 WAYNE AVE., PHILADELPHIA 44, PA.
DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR CO.
Offices in principal cities of the United States, Canada and throughout the world.

BROWN *Advanced Instrumentation* FOR BETTER PROCESSING
Product of MINNEAPOLIS Honeywell

for
any
application
where
stainless steel
is needed
only on the
contact side
nothing beats

INGACLAD
STAINLESS-CLAD STEEL



Magnified view of IngAclad Sheet to show proportion of stainlesstomild steel.

IngAclad provides maximum contact-side protection against rust, corrosion, abrasion, erosion —*at minimum cost.* Its 20% cladding of solid stainless steel, and 80% backing of mild steel mean lower cost, easier fabricating. Available in sheets 18 to 8 gauge, and in plates 3/16" to 1/4", inclusive. Full details on request.

ENGINEERING B-W PRODUCTION

INGERSOLL *Steel Division* • **Borg-Warner Corporation**
310 South Michigan Ave., Chicago 4, Ill.
***Plants:* Chicago, Illinois; New Castle, Indiana**
Kalamazoo, Michigan

New Precision Drill Press

A new 14-in. precision drill press has been announced by the *South Bend Lathe Works,* South Bend, Ind. Both bench and floor models are now in production. Most specifications are common to both models, each having a capacity to drill ½ in. in iron or steel at the center of a 14-in. circle.

A built-in light with independent switch provides shielded illumination for the work area. A quick-acting belt tension release lever simplifies changing the spindle speeds and returns the vertical mounted motor to its original position after each change, thus maintaining the same belt tension for each of the four cone pulley steps.

The spindle has a maximum travel of 4 in., with spindle speeds of 707, 1305, 2345 and 4322 rpm. The free-floating spindle design is said to prevent misalignment, side thrust and whip. The depth gage is graduated in sixteenths of an in., and has adjustable collars to control both the depth of feed and the length of the return stroke.

The bench model drill press has 10⅞-in. maximum chuck to table distance, 10⅞-in. table travel, 17-in. maximum chuck to base distance, 10¾-in. by 17¾-in. slotted base with precision ground top surface and 35½-in. over-all height.

The floor model has 40⅛-in. maximum chuck to table distance, 40⅛-in. table travel, 46½-in. maximum chuck to base distance, 15-in. by 21-in. slotted base with precision ground top surface, and 65½-in. over-all height.

Radial Drill Press for Drilling and Tapping Cast Iron

A new "bantam" size radial drill press, with a maximum operating capacity of 1 in. in cast iron, has been developed by the *Canedy-Otto Mfg. Co.,* Chicago Heights, Ill.

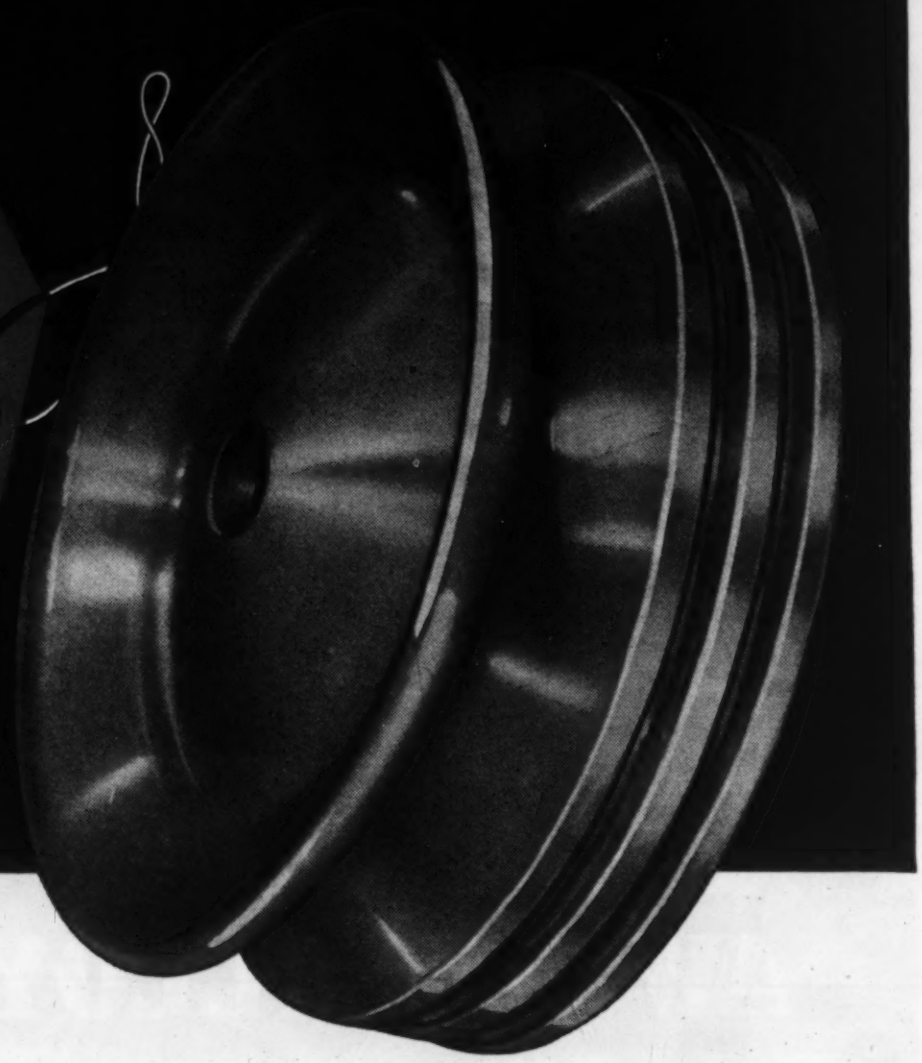
The new unit is available with a 3-ft. arm and 7-in. column; it has nine spindle speeds, and is equipped with a single speed motor and six rates of power feed. Two motors are used; one main driving motor for the head mechanism and one fractional hp. motor for the power elevating mechanism of the arm. All shafts are mounted on ball bearings, a total of 40 ball bearings being used in the machine.

The unit has a base of semi-cast steel casting, with integrally cast tank for adaptation of a coolant system. The 7-in. column is of tubular steel, ends welded into position.

Feed transmission is an independent unit held in position and in proper gear mesh with the pick-off power transmission gears. Feed clutch is a complete and independent unit, which permits feeding either downward or upward. Main drive clutch is a multiple disk friction dual type, offering forward and reverse rotation for convenience in tapping.

This wheel costs

34% LESS



in Alcoa Aluminum

"Daytona" model racing car manufactured by Black Industries, Cleveland, Ohio.

And gives this model racing car better pickup, faster speed!

The makers of this small-scale racing car achieved full-scale savings in wheel cost and weight by making them of Alcoa 11S-T3 Screw Machine Rod . . . the stock made specially for your automatics.

Wheels of Alcoa 11S-T3 cost 34% less than free-cutting brass wheels, 17% less than cadmium-plated steel. And weigh only ⅓ as much . . . the car starts quicker, runs longer and faster.

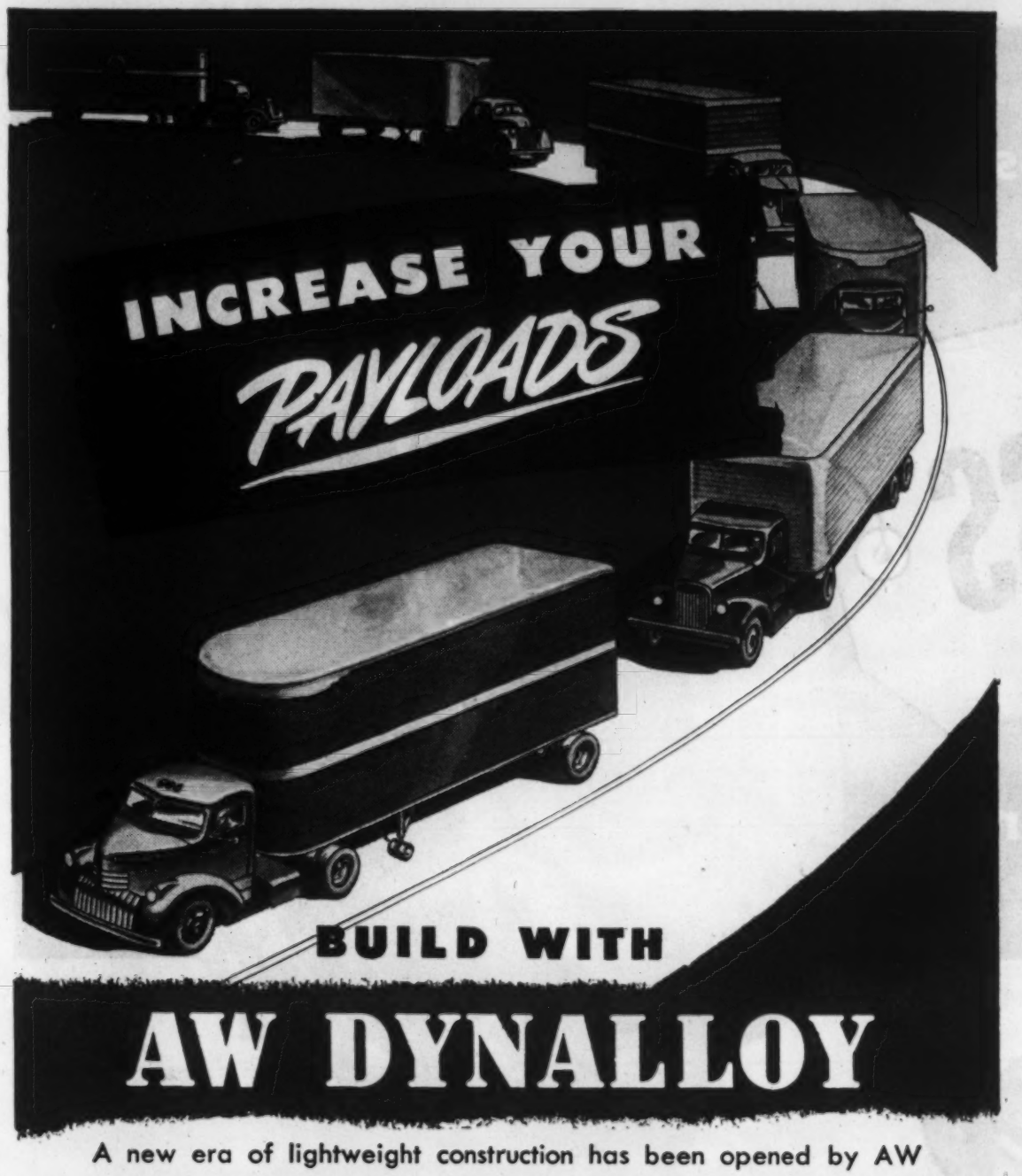
Figure the cost of one of your screw machine parts in Alcoa 11S-T3 Aluminum. It's the free-cutting aluminum alloy that gives fine chips, cannot foul tools, means faster cutting speeds and less wear on machines. Has a bright finish, needs no painting or rust-proofing.

You can get prompt shipment of Alcoa 11S-T3 Screw Machine Stock from warehouses in 24 strategic cities. Sales offices in 54 cities. ALUMINUM COMPANY OF AMERICA, 2162 Gulf Bldg., Pittsburgh 19, Pennsylvania.

MORE PEOPLE WANT **MORE** ALUMINUM FOR **MORE** USES THAN EVER

ALCOA FIRST IN ALUMINUM

IN EVERY COMMERCIAL FORM



A new era of lightweight construction has been opened by AW Dynalloy, the versatile high strength low alloy steel. Bigger payloads in trucks, freight cars and buses are now made possible. With AW Dynalloy you can reduce dead-weight as much as 40% without any reduction in strength or safety. This extremely tough steel has 4 to 6 times greater resistance to atmospheric corrosion than plain carbon steel and twice that of copper bearing mild steel. AW Dynalloy's excellent weldability, ductility and cold forming properties combined with its high resistance to impact, abrasion and fatigue make it exceptionally valuable for constructing vehicles, portable and stationary structures. Look into the advantages of AW Dynalloy now.

PHYSICAL PROPERTIES OF AW DYNALLOY	
Yield Point P.S.I. Minimum	50,000
Tensile Strength P.S.I.	65-80,000
Elongation in 2", %, Minimum	25.0
*Elongation in 8", %, Minimum	1,500,000 T. S.
Endurance Limit P.S.I.	45,000
Specimen Cold Bend, 180° @ diameter=1 thickness	

*For material under 5/16" to 3/16" inclusive, deduct 1.25 per cent for each decrease of 1/32" below 5/16" from the percentage of elongation in 8" specified above.

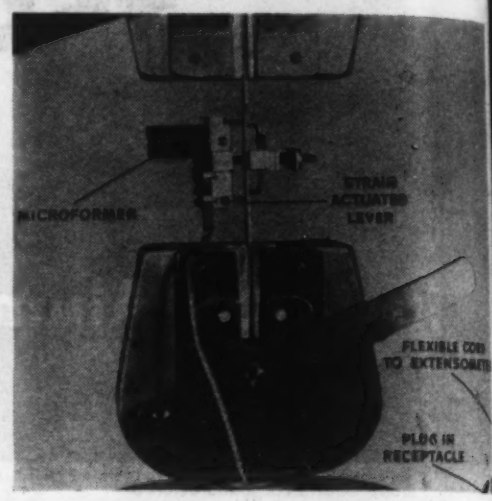
Write for your copy of our new Folder H-13. It contains helpful information and maximum sizes.

AW DYNALLOY
THE HIGH STRENGTH LOW ALLOY STEEL
A Product of ALAN WOOD STEEL COMPANY
CONSHOHOCKEN, PENNA.

Strain Recording System for Universal Testing Machines

A new stress-strain recorder controlled by two Microformers (variable miniature transformers) which are built into strain follower and recorder mechanisms has been developed by *Baldwin Locomotive Works*, Philadelphia 42. Principal application is in recording strains or deformation in test specimens subjected to tension, compression or flexure in Universal testing machines.

In operation, changing deformation in the specimen actuates the movable core of the strain-follower Microformer, which changes its output and unbalances an electrical circuit that includes the similar Microformer in the recorder. The resulting electrical impulse is amplified to drive a



The Microformer strain follower mounted on a tensile test specimen in a testing machine.

servo motor, which moves the core of the recorder Microformer, thus rebalancing the electrical circuit, and rotates the recorder drum in proportion to specimen deformation.

Corresponding values of applied load are recorded by movement of the stylus parallel to the axis of the recorder drum. The stylus is actuated mechanically by the testing machine load indicator. The direction of rotation of the recorder drum changes automatically with change in direction of deformation in the specimen. This facilitates the recording of tests in which specimens are loaded and unloaded.

Although the Microformer system is being used chiefly with strain-recording devices designed to magnify strain up to 1000 times or more, it is also adaptable for recording almost any pair of variables by using some index of each variable to actuate a Microformer.

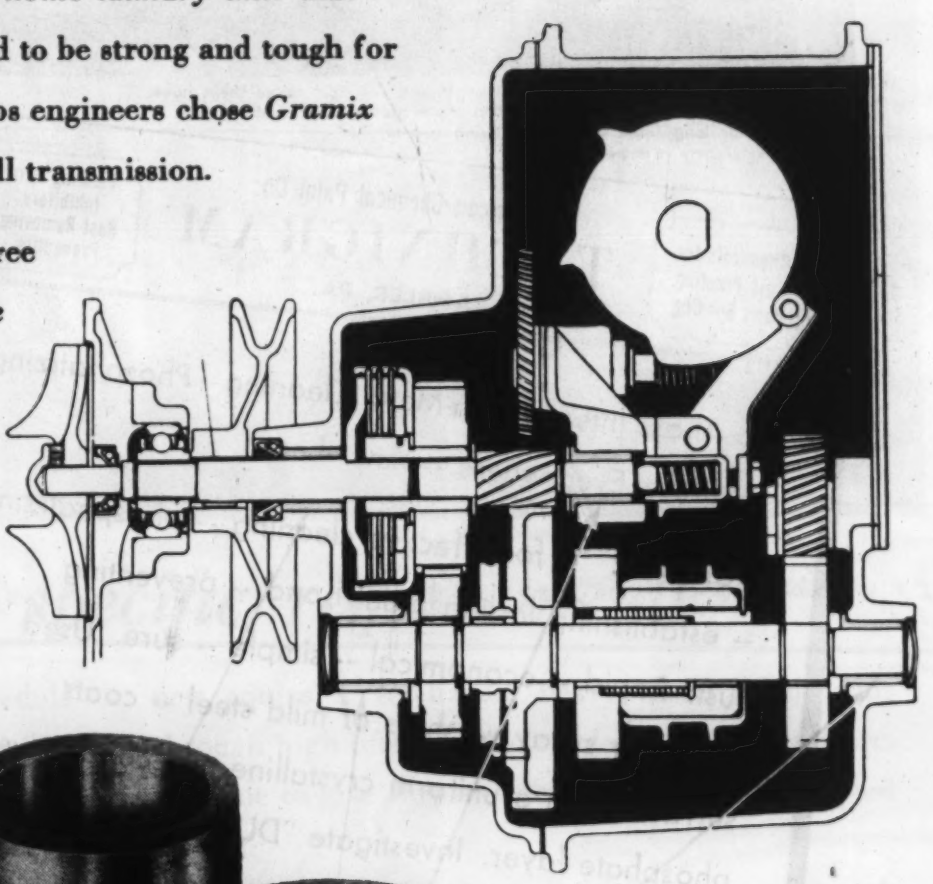
New General Purpose Tool and Die Steel

A new tool room specialty steel has been announced by the *Amalgamated Steel Corp.*, Newburgh Mill District, Cleveland 5. The new tool and die steel is said to have high

gramix helps LAUNDERALL wash, rinse, and dry clothes in one easy operation

For eight long years engineers of the F. L. Jacobs Co. tested materials and designs for Launderall, the *completely automatic home laundry unit* that washes, rinses, and spin dries clothes. Materials had to be strong and tough for dependability—yet low cost for economy. So Jacobs engineers chose *Gramix bearings* for use at six vital points in the Launderall transmission.

The Gramix bearings keep the shaft rotating free and easy without a whisper and virtually *eliminate repair troubles at these points.* And they're low-cost, because they are mass produced by simply die-pressing powdered metals to exact size. Surfaces are perfect for bearing, so no expensive machining or hand finishing is necessary. Strong, tough, Gramix parts may be *made in countless shapes and sizes,* many of them self-lubricating. Send us prints of your products and we'll show you where Gramix parts may improve performance and save you money. **Ask for your copy of the new 264 page catalog of Gramix parts and specifications.**



gramix

THE UNITED STATES GRAPHITE COMPANY • SAGINAW, MICHIGAN

Cleaned and phosphate-coated with "Duridine", these sheet steel range shells have acquired a thin, tight, hard, crystalline phosphate coating—the ideal preparation for long finish life and enduring beauty.
Photograph by courtesy of Hotpoint, Inc.

Chemicals for Rust Proofing Paint Bonding

American Chemical Paint Co.
TECHNIGRAM
AMBLER, PA.

Pickling Acid Inhibitors Rust Removing Preventing

To: Those Interested in Metal Cleaning -- Phosphatizing
Address: Everywhere -- Anywhere

"DURIDINE"*-- for effective cleaning -- phosphatizing -- establishing lasting paint bond -- preventing rust. Rapid -- economical -- simple -- sure. Used in power spray washers of mild steel -- coats surfaces with a uniform crystalline non-conductive phosphate layer. Investigate "DURIDINE" -- specify "DURIDINE". Full information on request.

Be sure to check on "DURIDINE" -- and the entire ACP family of metal treating chemicals -- for economical -- effective -- rapid production.

CHEMICALS ACP PROCESSES

RUST PROOFING AND PAINT BONDING
Granodine *
Duridine *
Rlodine *
Lithoform *
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RUST REMOVING AND PREVENTING
Deoxidine *
Peroline *

PICKLING ACID INHIBITORS
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Pioneering Research and Development Since 1914
AMERICAN CHEMICAL PAINT COMPANY
AMBLER, PA.
Manufacturers of Metallurgical, Agricultural and Pharmaceutical Chemicals

resistance to wear, and unusual toughness and strength with ductility to resist fatigue.

It is claimed that since the steel has the features of oil, air, and water hardening steels, it can be used for general purposes throughout tool and maintenance departments, eliminating the need for large inventories of a variety of steels. Since it may be quenched in oil, water or salt bath, almost any degree of hardness may be had.

The steel is said to weld and forge readily, and machine with an excellent finish. It is available in flats, rounds, squares, hexagons, octagons, and billets in various sizes.

New Aluminum Alloy Gives High Strength Without Heat Treatment

The development of a new aluminum casting alloy, called Tenzaloy, has been announced by *Federated Metals Div., American Smelting & Refining Co.,* 120 Broadway, New York. Nominal composition of the alloy is 0.8 copper, 0.4 magnesium, 8.0% zinc, and balance aluminum.

This aluminum-zinc alloy is said to furnish high strength and hardness without heat treatment, and foundries without heat treating equipment can produce castings having properties equivalent to those obtainable by conventional heat treating methods. The alloy can be cast with standard foundry procedure and equipment into sand, plaster, or permanent molds.

Other advantages claimed for the new alloy are exceptional machinability, excellent corrosion resistance, and extreme whiteness. The toughness of the alloy has permitted it to replace malleable iron in a number of applications. Products such as hose couplings, "C" clamps, electrical conduit fittings, and general hardware fittings are being made with this alloy.

New Potentiometers Have Applications in Laboratory and Plant

A new series of direct-reading, temperature-calibrated portable potentiometers for use in laboratory, plant and field has been announced by *Rubicon Co.,* 3642 Ridge Ave., Philadelphia 32. Ten standard models calibrated over a wide range of temperature, for use with copper-constantan, iron-constantan or chromel-alumel thermocouples, are available. Calibration may be had in either Centigrade or Fahrenheit degrees.

Four models have high-sensitivity, multiple-reflection galvanometers said to afford improvement in sensitivity over that previously available on low temperature ranges. Accuracy is attained by special structural features which maintain the thermocouple reference-junction and the automatic reference-junction compensator at substantially equal temperatures, irrespective of changes in the ambient temperature.

AUTOMATIC
STATION-TYPE
CONVEYORS
FOR
Bullard-Dunn Descaling . . . Pickling . . . Bright Dipping . . . Plating . . . Blackening . . . Heat Treating . . . Hot Tinning . . . Rubber Mould Cleaning . . . Phosphate Coating . . . Treatment Aluminum, Zinc

. . . *Engineered to specific requirements*

To keep a sequence of treatments right on schedule with the least effort, let an amazingly low-priced Bullard-Dunn Station-Type Conveyor, engineered to your specifications, take over the job.

It's fully automatic—with a timer which the operator can set to accurately time any cycle of treatments involving 5 to 20 stations. Manual operation by push-button control for the lifting, indexing and lowering functions is also possible.

It's hydraulic—with the oil reservoir built into the column for compactness. Its Geneva type of index motion produces smooth movement of work from station to station.

It's a Bullard Machine—made to conform with our machine tool standards. Ruggedness equips it to handle heavy, unbalanced loads through high lifts. Simplicity of design and few parts combine to give smooth operation and uninterrupted service.

It's job-tested—has been used for ten years for such processes as Bullard-Dunn descaling, pickling brass and bronze, tinning refrigerator condensers, soldering auto radiators, treating aluminum and zinc, and plating all kinds of metals.

Rotating cylinders and driving mechanism attachments are available for handling small parts.

For complete details write for Bulletin MM - BD. The Bullard Company, Bullard-Dunn Process Division, Bridgeport 2, Connecticut.

BULLARD

Bullard-Dunn Descales Without Dimensional Change

The Bullard-Dunn Process removes scale and oxide from ferrous metallic surfaces without attacking the work. Fast . . . thorough . . . economical . . . simple to operate. Investigate. Bulletin BD-42 tells story.

CREATES *NEW METHODS*
TO MAKE MACHINES DO MORE

OVER ONE HUNDRED YEARS OF CONTINUOUS SERVICE. ROUNDS, SQUARES, FLATS, HEXAGONS, OCTAGONS

BILLETS AND FORGINGS FOR PRODUCTION, TOOL ROOM AND MAINTENANCE REQUIREMENTS.

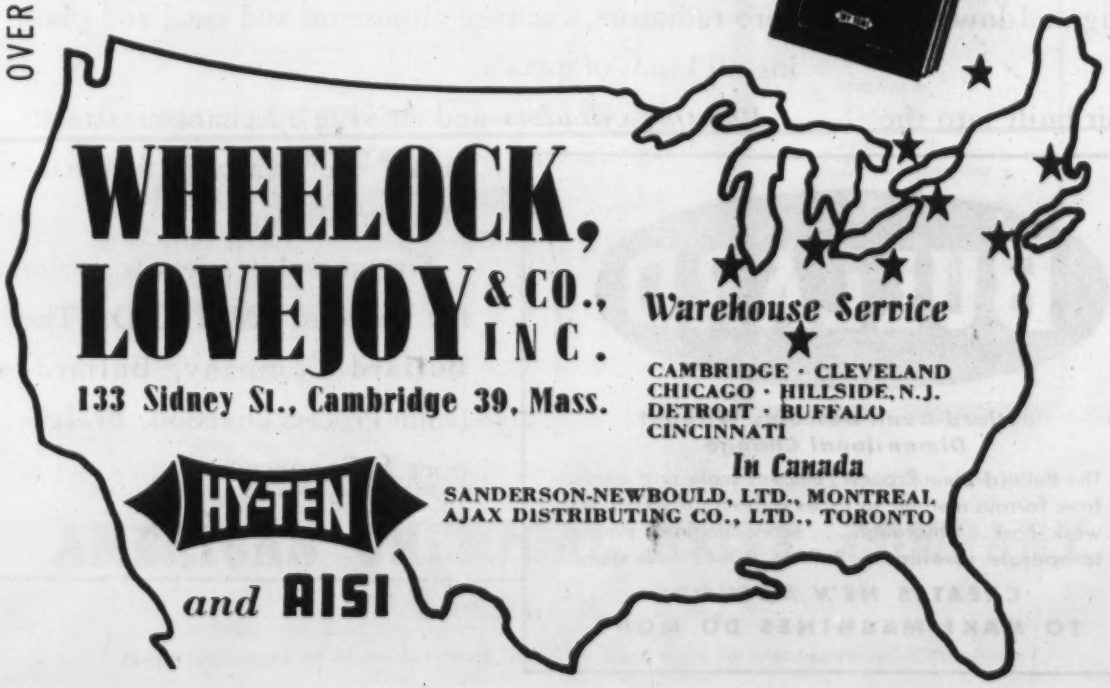
"B" No. 3X ALLOY STEEL IS

6 ways better!

HY-TEN "B" No. 3X is the ideal alloy for heavy duty parts because (1) it is supplied in the heat-treated condition to your desired physicals (2) it is readily machinable at high degrees of hardness (3) high finish is obtainable with either ordinary high speed or carbide tools (4) scaling, distortion and straightening are eliminated (5) it often eliminates grinding (6) rehandling and added expense of heat treating are avoided. HY-TEN "B" No. 3X is available immediately from warehouse stock at short notice.

WL *steels are metallurgically constant. This guarantees uniformity of chemistry, grain size, hardenability—thus eliminating costly changes in heat treating specifications.*

Write today for your FREE COPY of the Wheelock, Lovejoy Data Book. It contains complete technical information on grades, applications, physical properties, tests, heat treating, etc.



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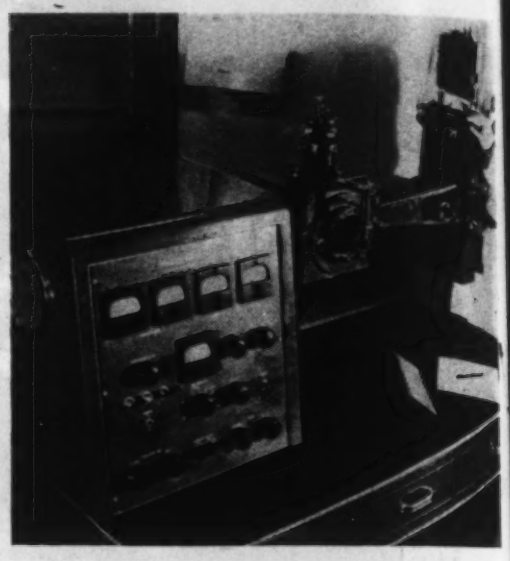
HY-TEN and AISI

Electron Diffraction Instrument Studies Surfaces and Thin Films

A new research tool designed to aid in the observation and measurement of surface conditions of metals, ceramics and plastics has been announced by the *Special Products Div., General Electric Co.*, Schenectady, N. Y. Called an electron diffraction instrument, it is valuable in the investigation of problems associated with corrosion, catalysts, lubricants, metallurgy, pigments, surface deposits, and graphite. It differs from the X-ray diffraction instrument, which analyzes thick specimens, in that the new instrument shows the crystal structure of surfaces and thin specimens up to 500 Angstrom units.

To operate, a beam of electrons is directed at the specimen being tested, and any resulting diffraction pattern is photographed.



View of the electron diffraction instrument showing method of reloading camera.

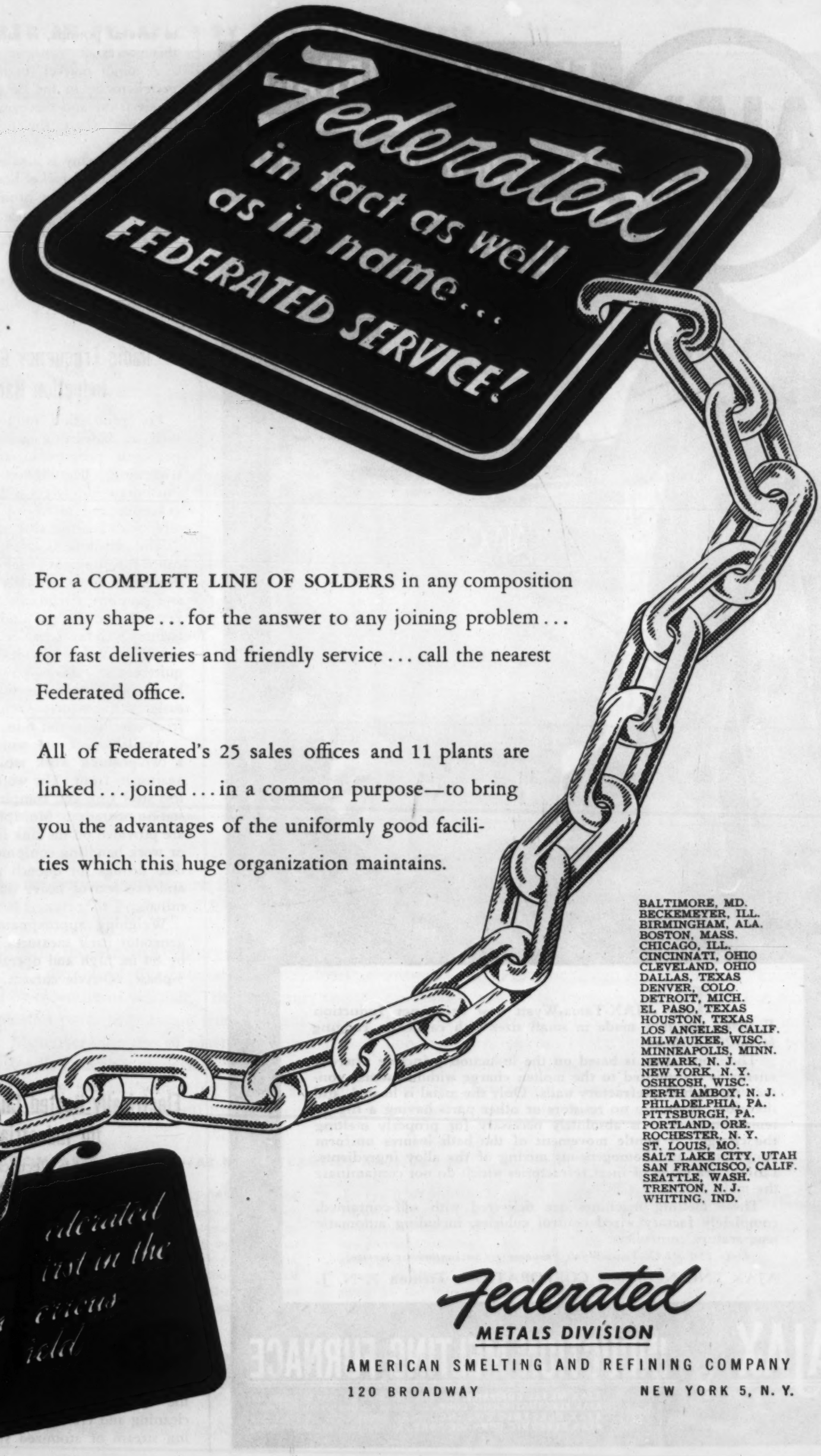
The pattern consists of rings whose diameter, intensity and orientation provide information for determining composition, orientation, and size of the crystals present.

The instrument consists of one unit containing vacuum chamber with specimen manipulator, visual and photographic recording camera, electron gun and beam focussing elements, regulated high voltage power supply, and complete vacuum pumping equipment.

The specimen chamber permits examition of specimens ranging from 0.1 to 4 in. in dia. In many cases, the instrument will detect and help identify the very first chemical changes before they are visible under a microscope or are detectable by other means.

Copper Castings Have Extra High Conductivity

A new technique in plaster mold casting now permits the making of precision copper castings with up to 95% conductivity. The new method, announced by *Universal Castings Corp.*, 5821 W. 66 St., Chicago, produces a non-porous casting with a smooth finished surface. Accurate detail of the most intricate parts, from a fraction of an ounce



For a **COMPLETE LINE OF SOLDERS** in any composition or any shape . . . for the answer to any joining problem . . . for fast deliveries and friendly service . . . call the nearest Federated office.

All of Federated's 25 sales offices and 11 plants are linked . . . joined . . . in a common purpose—to bring you the advantages of the uniformly good facilities which this huge organization maintains.

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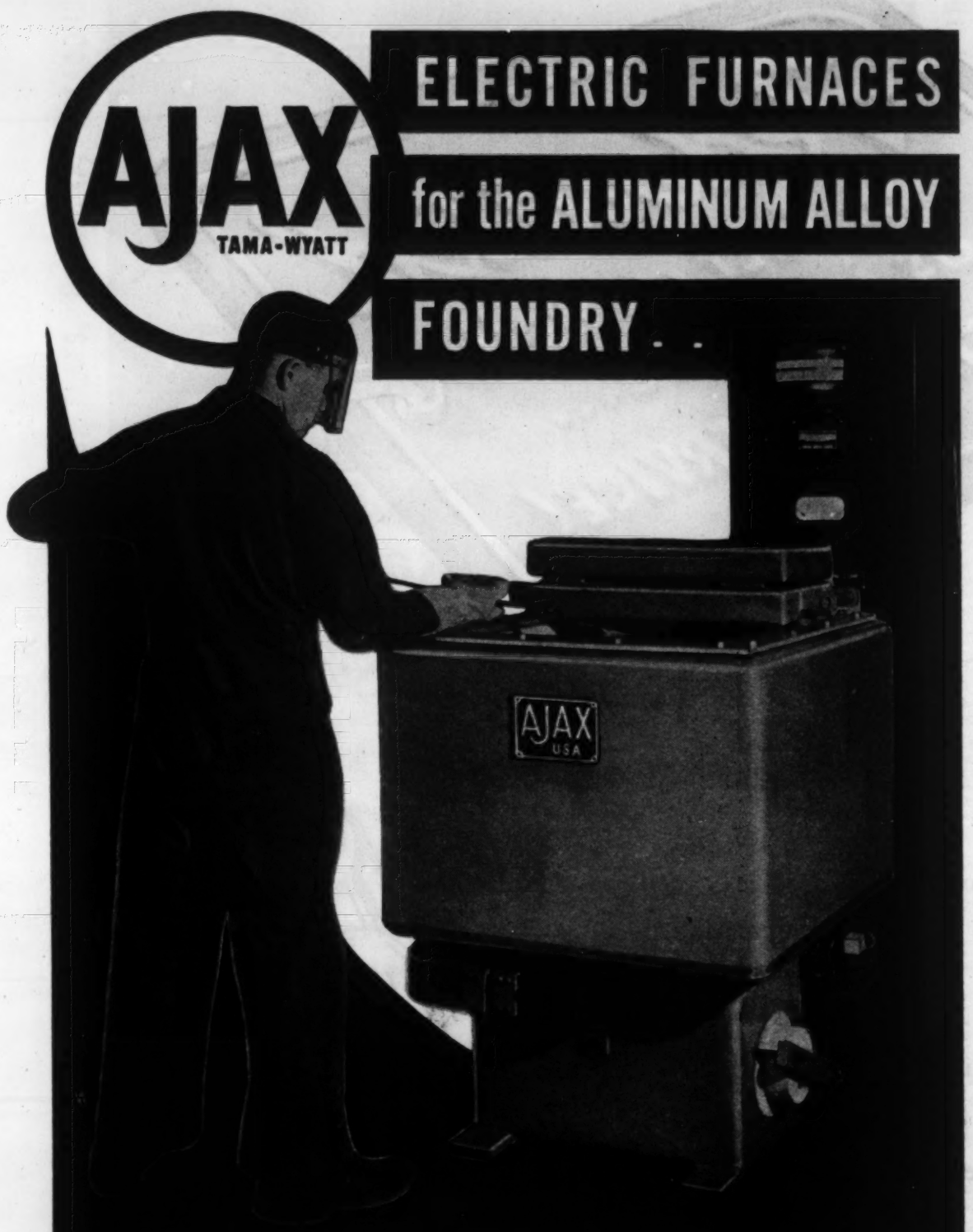


THE AJAX-Tama-Wyatt Low Frequency Induction Furnaces are now made in small sizes with capacities ranging from 20 to 35 kw.

Their operation is based on the induction principle whereby energy is transmitted to the molten charge without actual contact, through the refractory walls. Only the metal is heated, and therefore, there are no resistors or other parts having a higher temperature than is absolutely necessary for properly melting the charge. A gentle movement of the bath insures uniform temperature and homogeneous mixing of the alloy ingredients. Linings are made of inert refractories which do not contaminate the melt.

These melting machines are delivered with self-contained, completely factory wired control cubicles, including automatic temperature controllers.

Over 250 AJAX-Tama-Wyatt Furnaces are in continuous service.

AJAX ENGINEERING CORPORATION, Trenton 7, N. J.

AJAX TAMA-WYATT INDUCTION MELTING FURNACE

Associate Companies: AJAX METAL COMPANY, AJAX ELECTROTHERMIC CORP., AJAX ELECTRIC CO., INC., AJAX ELECTRIC FURNACE CORP.

to several pounds, is said to be assured by this process.

A major market for these castings is expected to be in the design field, especially in electrical and electronic instruments and machines where the high conductivity is desirable.

The company is also molding castings in 15 nickel-22% nickel brass alloy, aluminum bronze, manganese bronze, silicon bronze, nickel aluminum bronze, beryllium copper, and aluminum alloy.

Radio Frequency Generator for Induction Hardening

For production induction heating jobs such as hardening gears and automotive parts, or progressive and selective shaft hardening, *Westinghouse Electric Corp.*, Pittsburgh 30, offers a 50-kw., 450-kc. Rf generator and matching two-position work table with built-in sink.

The generator is assembled to include all control equipment, high voltage rectifiers, protective devices, oscillator tubes, Rf tank and coupling circuits in one complete unit. Features include an aluminum cabinet for lighter weight, complete Rf shielding to insure compliance with FCC radiation requirements, stepless power output control by the grid control rectifier, filtered air for easier maintenance, circuits fully protected from overloads, and 6-in. meters.

Available for use with the generator is a two-position work table, designed to fit against its front. The work table has a stainless steel sink and complete fittings for two station operation. Multiple mounting bosses are provided on the sink for easy installation or work handling equipment. The table has dual fittings for quench and cooling water and two sets of heavy duty RF output terminals.

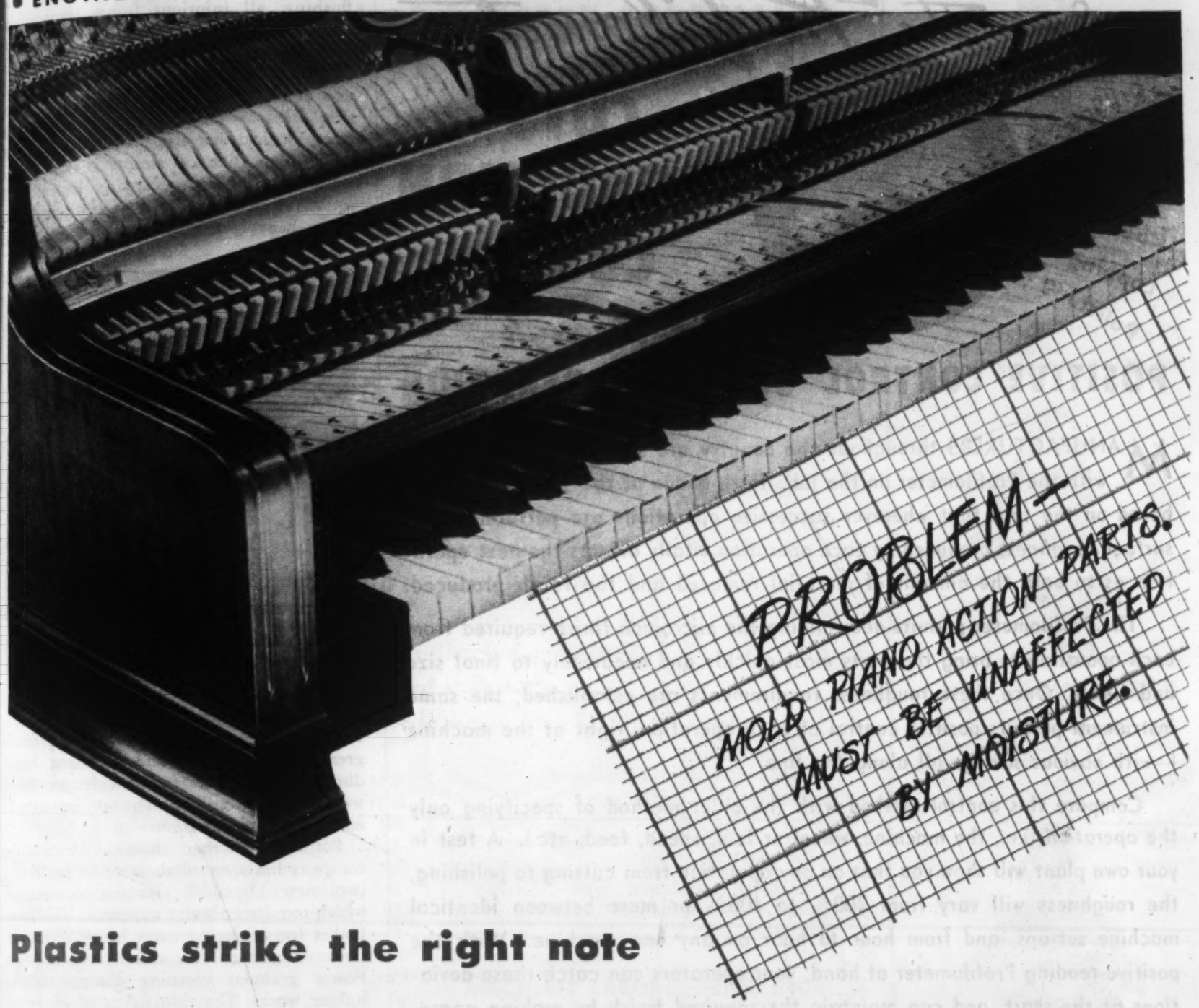
Weighing approximately 7000 lb., the generator itself measures 144 in. by 60 in. by 84 in. high and operates on 230/460-v. 3-phase, 60-cycle current.

Electrically Heated Chemical Cleaner for Industrial Use

A new portable electrically heated chemical cleaner that may be used for on-the-spot indoor cleaning of industrial machinery, conveyor systems, engines, and other equipment in factories and foundries is being manufactured by *Hartman Corp. of America*, 5141 Natural Bridge Ave., St. Louis.

Several advantages are said to be inherent in this new chemical cleaner: by the elimination of all smoke-stacks, flues and ventilators it becomes entirely portable indoors and out; a constant-pressure anti-splash spray nozzle automatically regulates the spray pattern for high temperature cleaning and creates a high-powered pulsating stream of atomized super-heated water

• ENGINEERED IN PLASTICS BY GENERAL ELECTRIC



Plastics strike the right note

• Now it's plastics for pianos! Plastics parts for piano actions, molded by General Electric for Pratt, Read & Co., Inc., are reported in a magazine article to represent "one of the greatest innovations in the piano industry in a century." For this application, G.E. selected a durable plastic material (ethyl-cellulose) that is unaffected by moisture or weather. The uniformity and stability of the plastics parts help assure true tone and keys that never stick. Moreover, the use of plastics speeded and simplified Pratt, Read's assembly process.

Whether *your* plastics job is "something special"—or an ordinary one—you can benefit by General Electric's *complete* plastics service. G.E. can carry your plans from drawing board to delivery platform—design, engineer and mold plastics parts to meet your own individual requirements.

If You Have a Plastics Problem—General Electric has the answer. General Electric design and production "know-how" can reduce your costs, improve your product. For more details, call your nearest G-E Sales Office. Or write for information and your free copy of the interesting, full-color booklet, "Problems and Solutions in Plastics," to Plastics Division, Chemical Department, General Electric Company, 1 Plastics Avenue, Pittsfield, Massachusetts.

G-E COMPLETE SERVICE—AT NO. 1 PLASTICS AVENUE

Backed by 53 years of experience. We've been designing and manufacturing plastics products since 1894. General Electric research facilities have expanded continually, working to develop new materials, new processes, new applications for plastics parts.

No. 1 Plastics Avenue—complete plastics service—engineering, design, mold-making. G-E industrial designers work with our engineers to create plastics parts, sound and good looking. Skilled mold-makers in G-E toolrooms average over 13 years experience.

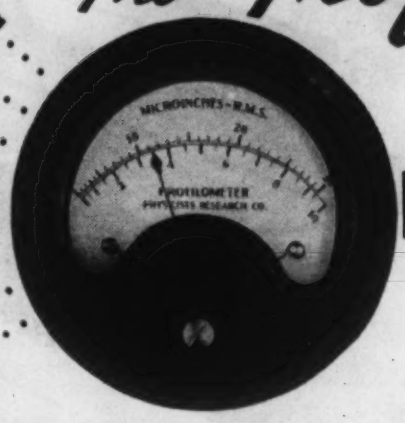
All types of plastics. Compression, injection, transfer and cold mold facilities . . . high and low pressure laminating . . . fabricating. G-E Quality Control—a byword in industry, means as many as 160 inspections and analyses for a single plastics part.

GENERAL ELECTRIC

CD47-H15

General Electric plastics factories are located in Scranton, Pa., Meriden, Conn., Coshocton, Ohio, Decatur, Ill., Taunton and Pittsfield, Mass.

Cutting . . .
Turning . . .
Drilling . . .
Boring . . .
Grinding . .
Honing . . .
Lapping . . .
Polishing . .



The Profilometer CUTS PRODUCTION COSTS *through* POSITIVE CONTROL OF EACH OPERATION

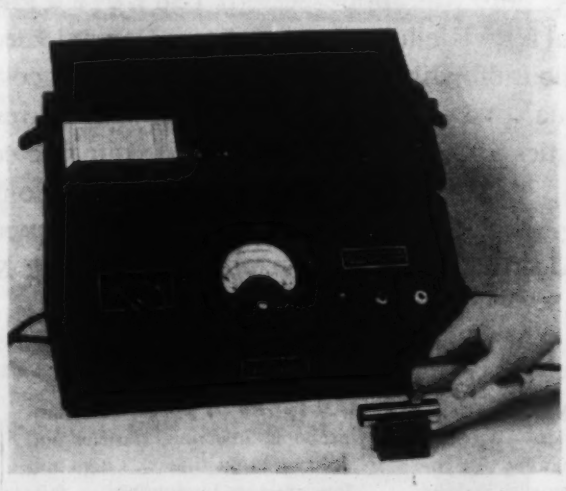
MANUFACTURERS throughout the country are saving time and money with the Profilometer on the job. Here is one of the "reasons why"—based on the fact that wherever successive operations are performed, the *surface roughness* produced by each operation vitally affects the next operation as to both the amount of material removed and the finish produced.

The Profilometer permits determining the *microinch finish* required from each operation to bring the parts most quickly and accurately to final size and finish. Once these roughness requirements are established, the same instrument permits positive control of each operation, right at the machine —with obvious savings all along the line.

Compare this control method with the older method of specifying only the *operation* (i.e., the machine, wheel or tool, speed, feed, etc.). A test in your own plant will show you that on *any* operation from cutting to polishing, the roughness will vary from 200% to 400% or more between identical machine set-ups, and from hour to hour on any one machine. With the positive-reading Profilometer at hand, your operators can catch these deviations at the start, and can maintain the required finish by making appropriate machine adjustments. This *positive control* gives greater production economy every time.

The Profilometer is very simple to operate. It is portable—can be used wherever most convenient. It is ruggedly built for shop use—gives *definite, accurate microinch readings* over long periods of time. And it is versatile—will measure practically any surface, external or internal, that can be produced by machining or grinding operations.

Write for full details on the above and other cost-saving applications . . . and arrange for a demonstration in your own plant.



The PROFILOMETER
TRADE NAME REGISTERED

PHYSICISTS RESEARCH COMPANY

ANN ARBOR • MICHIGAN

and chemical solution for cleaning and flushing; all injurious fumes, vapors and chemical-laden steam are eliminated, thus protecting nearby highly polished surfaces and preventing clouds of steam that impair and endanger the operator; fire and explosion hazards are prevented by multiple safety devices that also protect the operator.

The new chemical cleaner is built into a waist-high cabinet occupying less than 2 sq. ft. of floor space. It is equipped with 10-in. heavy pneumatic rubber tires, swivel

The electrically heated chemical cleaner is shown here in one of its many applications.

caster with brake for maximum maneuverability, 20-ft. Neoprene high-pressure grease-resistant hose, and sufficient heavy duty rubber cable to provide an 80-ft. working area, and which can be supplemented by an extension.

For use with their chemical cleaner, the company has also collaborated in perfecting two new chemical cleaning compounds which require no water softeners—Hi-Power Flakes for removing extra heavy accumulations of grease, dirt and muck; and Lo-Power granular cleaning compounds for lighter work. The thin flakes of Hi-Power are soluble in hot or cold water and contain only balanced and buffered chemicals to provide maximum safety on metal surfaces. Neither Hi-Power Flakes nor Lo-Power Granular contain any free caustic soda in the solution.

Vertical Spindle Grinder

A new type 72-in. vertical spindle grinder designed for grinding cast iron gear housings has been announced by *Charles H. Besly & Co.*, 118-124 N. Clinton St., Chicago. Gear housings ground on this machine are said to compare favorably with work done previously by skilled manual grinding in both finish and flatness (within 0.003 in.).

The new grinder features a power-driven rotary fixture into which the operator places the casting. The rotating fixture and revolving work holders carry the castings through the grinding cycle at one revolution every 60 sec., increasing output from a previous 36 to 240 pieces an hr. Four pieces are ground simultaneously. Approximately 1/32 in. is removed. When smaller castings are ground, two or more can be placed in each work holder.

NOW... RF HEATING TUBES DESIGNED and PROCESSED ESPECIALLY FOR RF HEATING PURPOSES

To Machlett Laboratories the tube needs of the RF heating industry have been a challenege—no less than they have been a source of deep concern to the industry itself. The electronic heating industry has now grown to such importance as to require—and merit—the best the electron tube industry can produce . . . and here the "best" *must* mean tubes designed and processed *especially* for its needs, not "hand-me-downs," no matter how high in quality, from communications or other fields.

For this reason . . .

MACHLETT LABORATORIES

are Privileged to Announce

their initial step in a planned program
to provide the* RF *heating industry
for the first time
with a line of tubes designed, processed,
and serviced exclusively
for its use

Machlett Laboratories' announcement several months ago of RF Heating Tube Types ML-5604 and ML-5619 constituted the first tangible recognition by the tube industry of the special requirements of the electronic heating field. These tubes, featuring above all else an unquestioned ability to handle—without penalty to life or performance—the most severe load mis-matching and the unusual physical conditions inherent in industrial service, marked the beginning of a new concept of service to this growing industry. Unmatched in mechanical ruggedness, they embody materially heavier sections, sturdier grid, cathode and terminal construction, and principles of tube design and processing which assure better performance and longer life.

These same principles are now embodied in five new tubes—ML-5658, ML-5666, ML-5667, ML-5668 and ML-5669. Thus there is now available—*for the first time*—for both initial installation and for replacement, for all induction and dielectric heating purposes from 5 to 50 KW, a selection of tubes, each of which is custom-made for the job it has to do.

☆ ☆ ☆

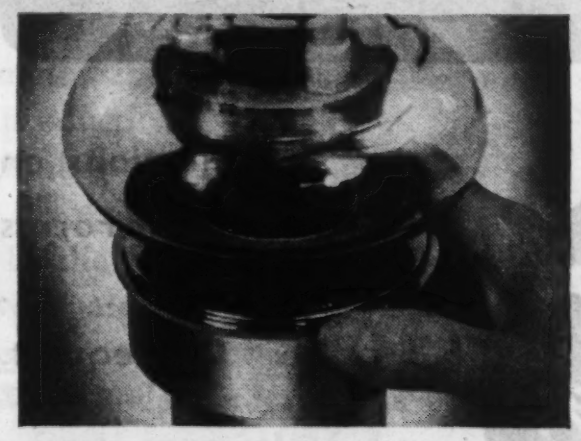
Machlett RF Heating Tubes will be supplied—where desired—with scientifically-designed terminal connectors affixed to the tubes at the factory. Flexible leads will be permanently attached in lengths to meet equipment manufacturers' requirements.

☆ ☆ ☆

To the RF Heating Equipment manufacturer these Machlett electron tubes and accessories will provide the first real freedom from "tube worries" and assure user satisfaction. They will contribute to demonstrating the effectiveness and economy of electronic heating. Priced only slightly higher than the standard communication tubes generally sold for this purpose, they will prove lowest in cost through better performance and materially longer life.

Write for complete technical data on this new line of tubes and accessories A Machlett Application Engineer will gladly visit you at your request.

MACHLETT LABORATORIES, INC.
Springdale, Connecticut



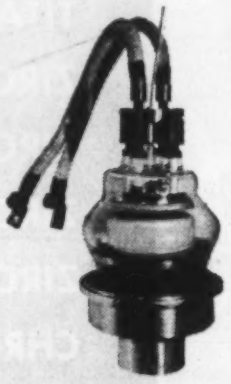
AUTOMATIC SEAL WATER JACKET. No tools needed to open and close the new Machlett water jacket. No worry about tube breakage or water leakage. Jacket cannot be opened unless water pressure is off, nor closed unless tube is properly seated. Your hand opens and closes a perfectly safe seal with just a single twist.

MACHLETT

***50* Years of Electron Tube Experience**

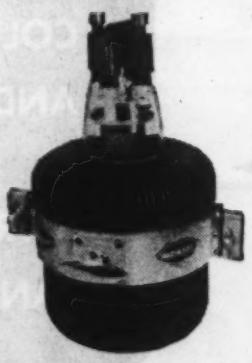
ML-5619 RF HEATING TRIODE, water cooled with automatic seal jacket, or for forced-air cooling (ML-5604).

Maximum Input ..... 32.5 KW
Maximum Plate Dissipation (ML-5619) .... 20 KW
Maximum Plate Dissipation (ML-5604) .... 10 KW



ML-5658 RF HEATING TRIODE

Maximum Input ..... 60 KW
Maximum Plate Dissipation.. 20 KW
(Will replace Type 880 without equipment modifications)
Automatic seal water jacket as shown.



ML-5667 FORCED-AIR COOLED TRIODE, available for water cooling ML-5666, with automatic seal jacket.

Maximum Input ..... 20 KW
Maximum Plate Dissipation (ML-5667) .... 7.5 KW
Maximum Plate Dissipation (ML-5666) .... 12.5 KW
(Will replace Types 889A and 889RA without equipment modifications)

ML-5668 WATER-COOLED RF HEATING TRIODE, available with automatic seal jacket.

Maximum Input ..... 28 KW
Maximum Plate Dissipation . 20 KW
(Will replace Types 892 and 892R [by ML-5669] without equipment modifications)

COLUMBIUM
TANTALUM
TITANIUM
ZIRCONIUM

•

COLUMBIUM — COBALT
TITANIUM — COBALT
TITANIUM — COPPER
TITANIUM — NICKEL
ZIRCONIUM — COBALT
ZIRCONIUM — COPPER
ZIRCONIUM — MAGNESIUM
ZIRCONIUM — NICKEL
CHROMIUM — COBALT
CHROMIUM — NICKEL

•

HYDRIDES OF BARIUM, CALCIUM, COLUMBIUM, TANTALUM, TITANIUM AND ZIRCONIUM

•

NITRIDES OF CALCIUM, MAGNESIUM, TANTALUM, TITANIUM AND ZIRCONIUM

Materials for the Metallurgy of Tomorrow

Specifications on Available Forms Furnished . . . On Request.

METAL HYDRIDES INC.

FACTORY AND SALES OFFICES, 12-24 CONGRESS ST., BEVERLY, MASS.

New Process Applies Metal Films by Evaporation Continuously

A continuous process of applying, by evaporation, films of metal to the surfaces of sheet materials has been developed by *National Research Corp.*, 70 Memorial Drive, Cambridge, Mass. While such metals as aluminum have long been applied to the surface of glass or other material by batch methods, their continuous application to continuous rolls at high speeds has not been practical until now. This new process applies extremely thin films of aluminum, silver, gold, zinc, copper and other metals to the surfaces of papers, textiles and various plastic sheets at linear speeds of hundreds of ft. per min.

Because of the thinness of the film, the flexibility of the base material is not affected and the moisture vapor transmission is reduced. Adhesion varies with the material. Finish is limited only by that of the base material, and on polished surfaces the brilliance exceeds that of foil. The method is said to be inherently more practical and economical than the rolling of foil, and its cost is materially lower.

The process promises to find uses in functional packaging and in the electronics field. Capacitors or condensers formed from zinc-coated paper have selfhealing qualities, promising longer life to such units.

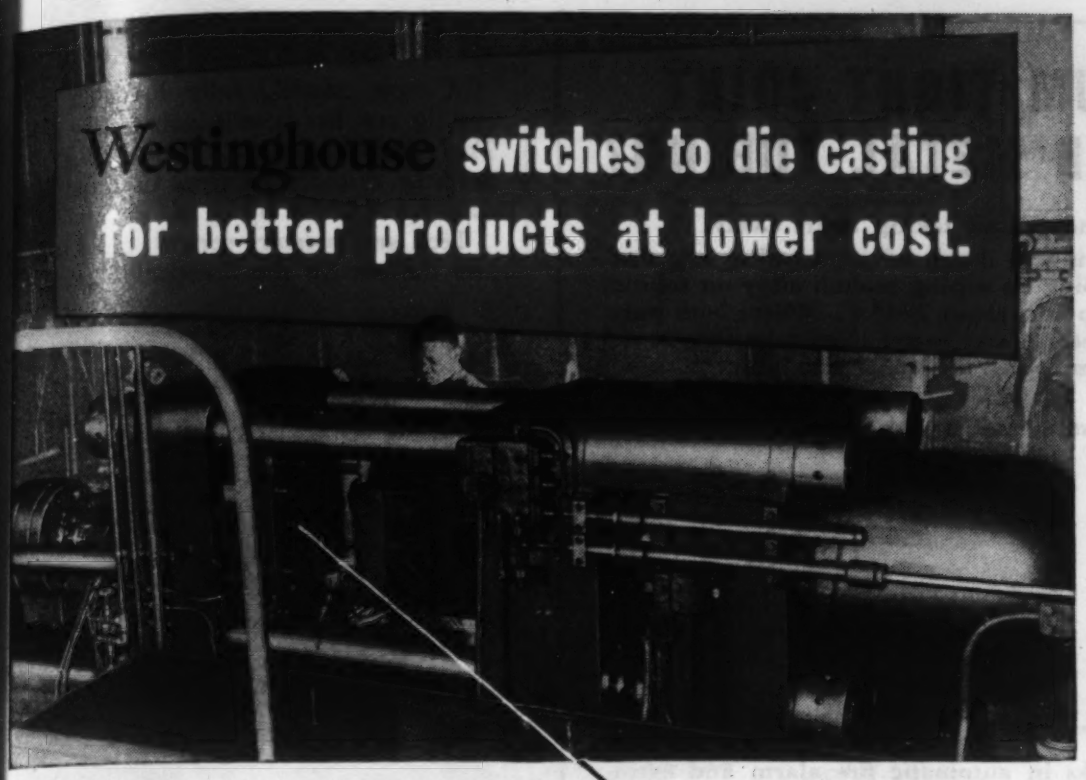
New Press-Type Welder Available With "Three-Phase" Control

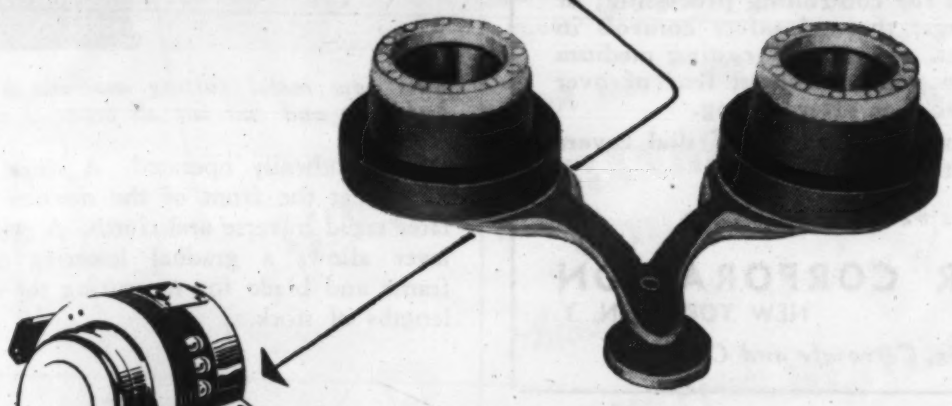
A new series of press-type welders has been announced by *Sciaky Bros.*, 4915 West 67 St., Chicago. Utilizing a standard frame size, these welders offer a choice of five power ratings (20, 30, 40, 50 and 75 kva.) and four throat depths (12, 18, 24 and 30 in.). Capacities on mild steel range from 0.016 up to 0.125 in.

If desired, the welders can be furnished with "three-phase" control. This feature is said to reduce the required power rating by 50% and operates on a balanced three-phase load at a power factor of 85% or better. This control also permits the welding of aluminum, brass, etc., with nominal power supply. This series of small machines completes a line of spot, seam and projection welders which range in size up to heavy duty machines capable of welding two thicknesses of 3/8-in. steel with a power demand of only 500 kva.

Standard features of the machine include: automatic electronic control of the welding sequence; frame of 3/4-in. steel plate, designed and ribbed to maintain alignment and reduce deflection; cast and precision-machined head with tapered bushings to compensate for wear. The welders are self-contained; controls are mounted in a hinged side cabinet with dials convenient to operator.

Optional equipment include a pre-heat and post-heat sequence which permits the welding of scaly and high carbon steel. Welders up to 24-in. throat depth can be furnished with T-slotted platens for projection welding.





Westinghouse engineers faced a tough job! Lack of copper held up production of badly needed refrigerator motors. H-P-M machines licked the problem by high-speed die casting of motor rotors—two at a time—using aluminum instead of copper. Westinghouse gained three ways—a better product . . . less labor . . . lower material cost—and gave the motor industry a better, less expensive way to higher production.

While stamping and machining operations may have an extremely important place in your manufacturing, many components *can* be die cast faster, better and at less cost. Why not investigate the possibilities for *your* products? Regardless of weight or size, die casting may be the answer. Write today or call in a nearby H-P-M engineer for a frank appraisal of die casting possibilities in *your* plant.

THE HYDRAULIC PRESS MANUFACTURING CO.
1054 Marion Road • Mount Gilead, Ohio, U. S. A.
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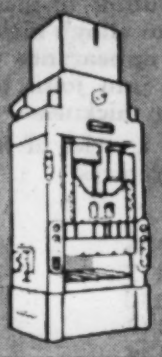
Bulletin 4805A shows how H-P-M Die Casting Machines save you time and money. Write today for your copy.

HPM

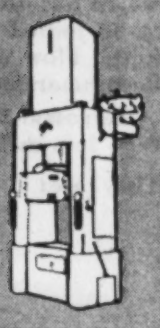
***ALL-HYDRAULIC SELF-CONTAINED* DIE CASTING MACHINES**

REVOLUTIONIZING PRODUCTION WITH HYDRAULICS SINCE 1877

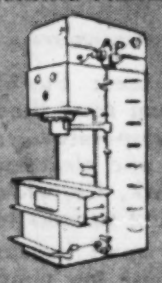
WHEREVER YOUR PRODUCTION CALLS FOR PRESSURE PROCESSING H-P-M EQUIPMENT DOES IT BETTER—FASTER—AT LOWER COST



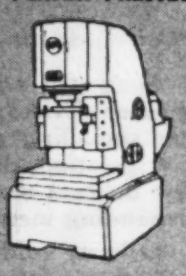
DOUBLE-ACTION DRAWING PRESSES



SINGLE-ACTION PLATEN PRESSES



FORCING PRESSES



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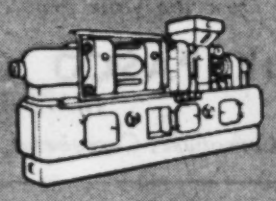
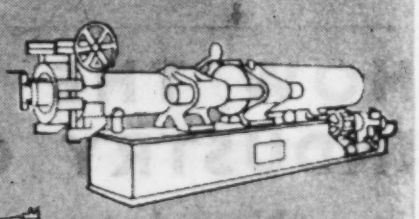
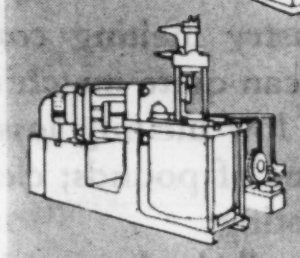


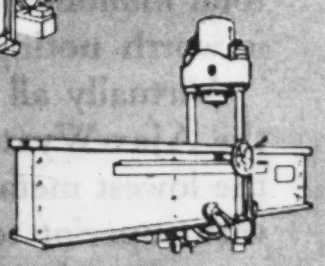
PLASTICS MOLDING MACHINES



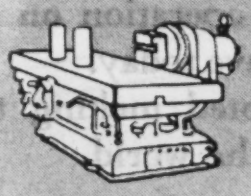
EXTRUDING PRESSES



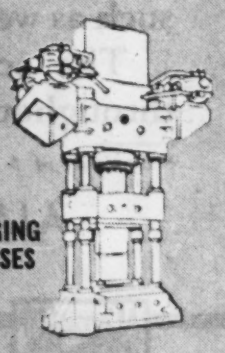
DIE CASTING MACHINES



STRAIGHTENING PRESSES



BENDING PRESSES



FORGING PRESSES

Write for **BULLETINS DESCRIBING THESE H-P-M PRESSES**

REQUIRE A VACUUM TIGHT JOINT BETWEEN GLASS AND METAL TUBING?

Cerroseal-35 will do the job quickly and permit taking apart easily.

The procedure: tin inside of metal tubing to depth of joint, using any flux. Wash off all flux. Tin outside of glass tubing by wiping molten alloy on tubing, which has been warmed to alloy's melting point, about 244° F. Warm both parts to be joined to give an appearance of wetness and insert glass tube into metal tube. Flow excess alloy into joint to completely fill space and allow to cool. Recommended alloy film thickness—.002" to .004".

Cerroseal-35 is one of a series of interesting and useful Indium alloys having very low melting temperatures.

They are:	Melting Temperature
Cerrolow-105	*105°F
" -117	117°F
" -136	136°F
" -147	*147°F
" -174	174°F
Cerroseal- 35	*244°F
" - 25	*294°F

*Non-eutectic alloys—yield temperatures are those given.

Suggested and actual uses: Fusible links in automatic fire alarm and extinguisher devices; in manual reset thermal switches for controlling processing; or for signalling rise of temperature, as in bearings; thermal safety controls in refrigeration, diathermy and electronic equipment. As a proof casting medium for delicate machine work, Cerrolow-117 can be poured without fear of over expanding metal parts and shrinks but .0002" per inch after casting.

Delicate soldering in small instruments will not be disturbed if dial covers are sealed with one of these low temperature melting alloys.

Describe your problem. Perhaps we can help.

CERRO DE PASCO COPPER CORPORATION

DEPARTMENT 8 — 40 WALL STREET — NEW YORK 5, N. Y.

Makers of Cerrobase, Cerrobend, Cerromatrix, Cerrosafe and Cerrotru.

HOW THE WROUGHT BRASS INDUSTRY CONSERVES METAL

No industry melting *commensurate tonnage** of vital metal can quite match the brass mills for conservation and low melting losses. The savings of metal total millions of pounds; clearly the method they use is worth noting:

Virtually all the brass mills in North America use the Ajax-Wyatt induction melting furnace, for it has the lowest metal losses in the field — less than 1% — with superior temperature control and unapproached economy of operation on high production schedules such as we have today.

The accepted melting tool in brass rolling mills throughout the world.

* *Upwards of 5 billion pounds annually.*

AJAX ELECTRIC FURNACE CORP.

1108 Frankford Avenue • Philadelphia 25, Pa.

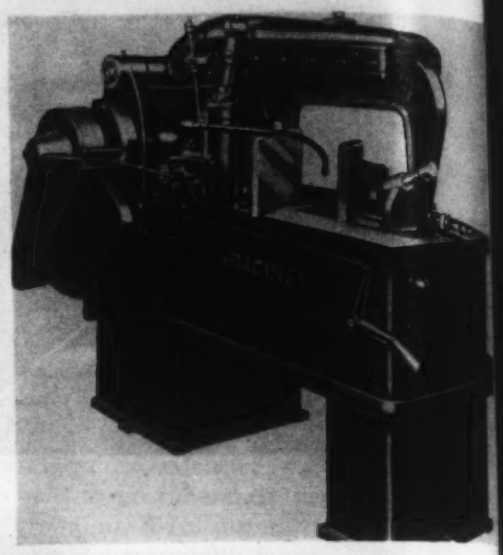
THE AJAX WYATT INDUCTION MELTING FURNACE

ASSOCIATE COMPANIES: AJAX METAL COMPANY, Non-Ferrous Ingot Metals and Alloys for Foundry Use; AJAX ELECTROTHERMIC CORPORATION, Ajax-Northrup High Frequency Induction Furnaces; AJAX ELECTRIC COMPANY, INC., The Ajax-Hultgren Electric Salt Bath Furnace; AJAX ENGINEERING CORPORATION, Ajax-Tama-Wyatt Aluminum Melting Induction Furnaces

Metal Cutting Machine Cuts All Metals

A new model, fully hydraulic metal cutting saw has been announced by *Racine Tool & Machine Co.*, Racine, Wis. This machine can cut all types of metal in all sizes up to 10 in. by 10 in.

Feed and pressure control, rapid traverse and the lift on the non-cutting stroke are



This new metal cutting machine is fully hydraulic and can cut all types of metals

all hydraulically operated. A single lever located at the front of the machine regulates rapid traverse and clutch. A push-pull lever allows a gradual lowering of the frame and blade for measuring the cut-off lengths of stock.

Hardness Tester Checks 800 Pieces Per Hour

A Brinell testing machine capable of checking up to 800 pieces per hr. and of parts varying in diameter and thickness as much as ¾ in., without moving the elevating screw, has been announced by *Steel City Testing Machines, Inc.*, 8843 Livernois, Detroit 4. This machine is motor driven, hydraulically operated and so constructed that the operator cannot remove the specimen being tested before the full load has been applied to the penetrator.

The load is held for a pre-determined time cycle (adjustable from 2 to 15-sec. duration) after which time the penetrator automatically reverses itself to starting position, ready for the next test. Specimens or parts which are alike in thickness or diameter within ¾ in. are tested without moving the elevating screw. The machine is equipped with a comparator indicator which eliminates the necessity of using the Brinell microscope in production testing.

The machine can be furnished with a foot or knee type starter switch. Throat opening is 6 in. and maximum vertical opening is 14 in. Standard equipment includes flat and vee type anvils.

*Trade Mark Reg. U. S. Pat. Off.

A Division of

THE OHIO CRANKSHAFT COMPANY

CLEVELAND, OHIO

Announces the purchase of

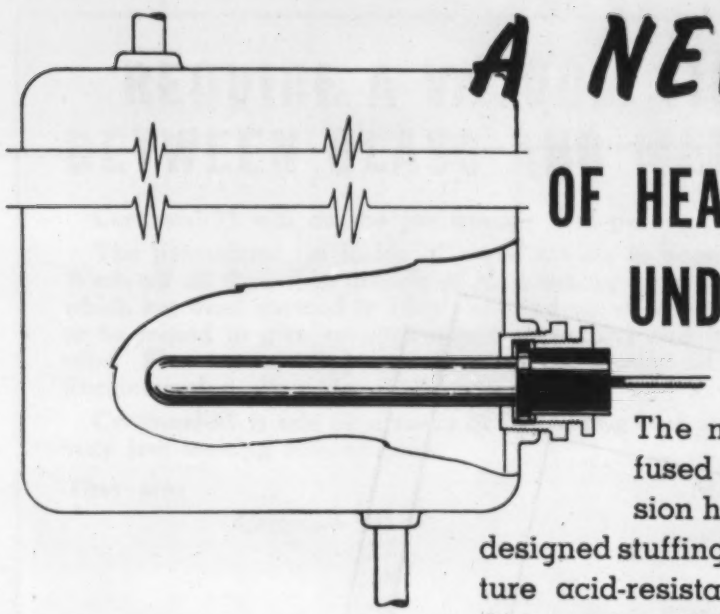
THE BUDD INDUCTION HEATING DIVISION

OF THE BUDD COMPANY

★

This expansion of our facilities will permit greater service to metal working plants seeking ways to lower costs, speed production and improve products.

★



A NEW WAY OF HEATING LIQUIDS UNDER PRESSURE

The new Amersil* opaque fused quartz electric immersion heater, with its specially designed stuffing box, and high temperature acid-resistant resilient head, produces new efficiency standards when heating liquids under pressure.

In vessels or tanks limited in size, the heater occupies a minimum of space within the liquid or gas area. It provides accurate control over a wide temperature range.

Write today to Dept. "M" for new bulletin on Amersil heaters.

*Trade Name Registered

AMERSIL COMPANY Inc.

ENGELHARD

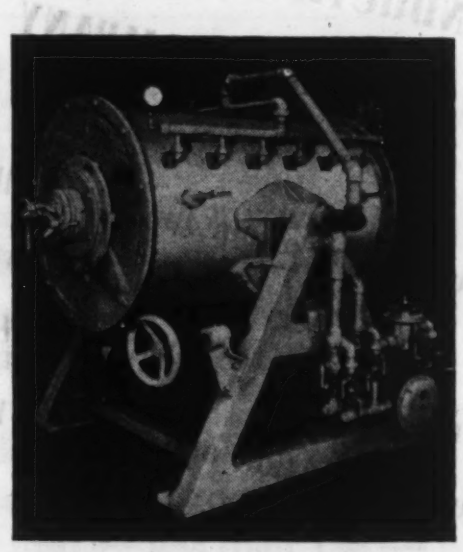
CHESTNUT AVENUE HILLSIDE 5, N. J.

ROTARY GAS CARBURIZERS

A "First" by A.G.F. Co.

Versatility is the outstanding characteristic of AGF Rotary Gas Carburizing Furnaces, which may be used not only for carburizing, but also for clean hardening, normalizing, annealing, and other general or atmospheric work without modification to the furnace of any kind.

Uniform heating of the work is assured by the gentle mixing produced by the rotary action of the retort, which is heated by numerous carefully distributed and balanced gas burners. Carburizing or atmosphere gas is introduced through a simply-designed, trouble-free connection.



Charging and discharging of the work is accomplished by means of a tilting feature, which is power-driven on the larger models. The retort remains within the heat at all times.

The furnace shown above is the latest, improved AGF Rotary Gas Carburizer, batch type, with new maintenance-free roller bearing retort support.

AGF gas carburizing equipment also includes Continuous Rotary Furnaces and Vertical Retort Carburizers. Write for literature.

American Gas Furnace Co.

Main Office and Works: Elizabeth, New Jersey

News of...

ENGINEERS COMPANIES SOCIETIES

Engineers

Le Verne Verzier has joined Lupomatic Industries, Inc. as director of development, being an expert on abrasive compounds for finishing, both in the laboratory and in the field. He will work in the development of the science of tumbling and equipment needed. He is a member of chemical, electrochemical and electroplaters' societies.

Morgan Sibbett, formerly an officer in the materiel procurement branch, U. S. Army, has joined the Battelle Memorial Institute, where he will make economic appraisals of new engineering developments for industrial and governmental sponsors. He belongs to the American Society of Mechanical Engineers and Tau Beta Pi, honorary engineering society.

Alwyn A. Throckmorton, former deputy director, Metals Div., War Assets Administration, has been named manager of scrap procurement, Kaiser Aluminum Div., Permanente Metals Corp. After previous Governmental service in the metals field, he joined RFC in 1944 to handle metals disposals.

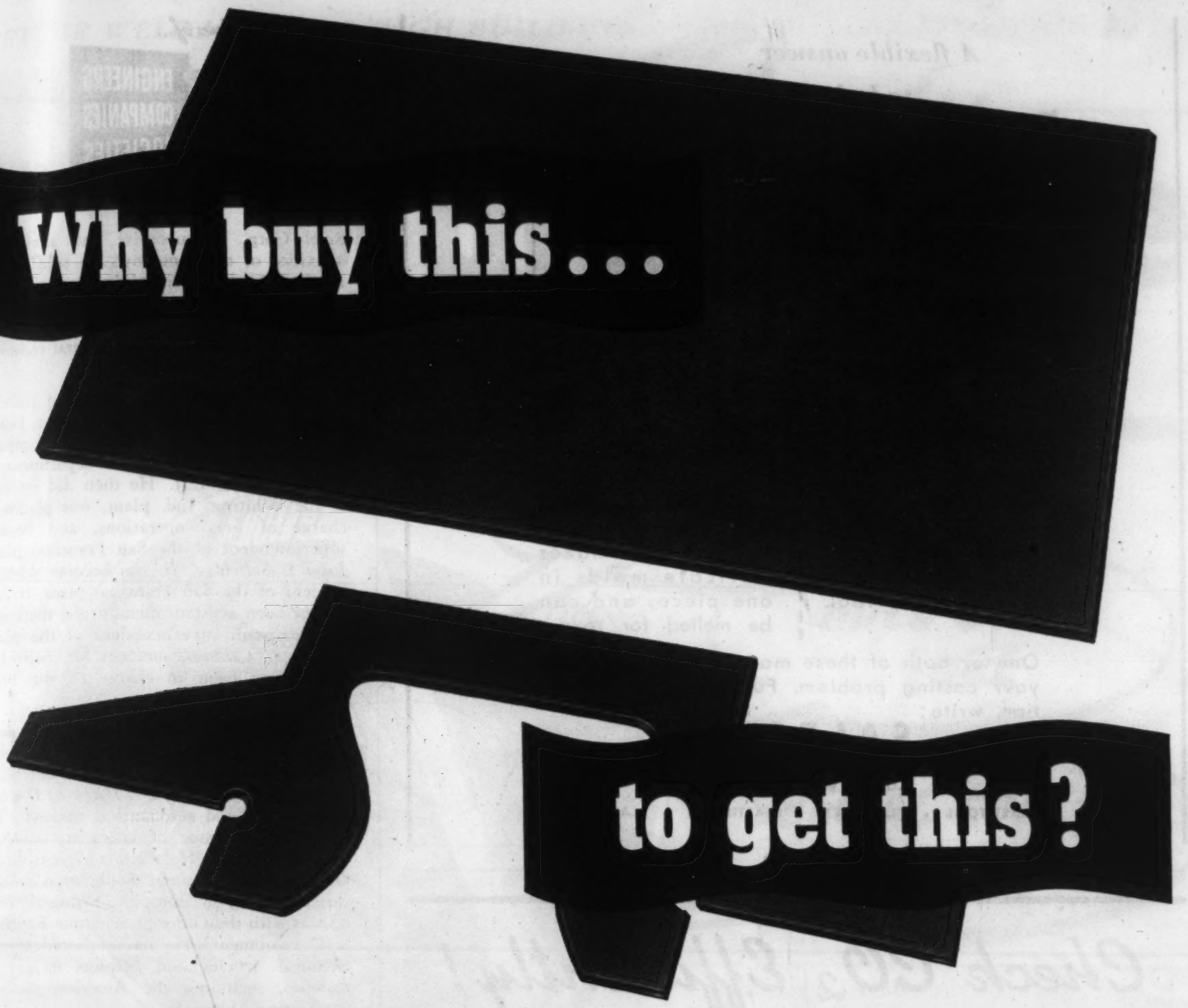
Samuel G. Baker has been promoted to general manager, Electrochemicals Dept., E. I. du Pont de Nemours & Co., Inc. He joined the department in 1943 after considerable sales experience with the company.

Harry A. Balke, formerly with the American Bridge Co., has opened up an office as consulting engineer at 800 Broadway, Cincinnati. Structural design service on steel and concrete bridges, buildings and unusual structures is offered.

N. George Belury has been made vice president, Engineered Castings Div., American Brake Shoe Co., having been sales manager. *Harry C. Platt* is the new works manager, having been formerly division metallurgist. He has been in the metallurgical department since 1942, when he was graduated from the Massachusetts Institute of Technology.

Jerry M. Gruitch has been appointed director of research and development, American Car & Foundry Co. His career started with the Ford Motor Co. in 1921 as apprentice toolmaker. During the war he was in the ordnance technical research and developments section of the Army Air Forces, becoming chief in 1944.

Frank Leslie Estep, active in the steel industry since 1900 as electrical and mechanical engineer, has joined the Barium



Instead of buying the plate and shaping it in your own plant, buy By-Products Steel Plate Shapes and save time and money!

Here's how: Just send us the drawing of the part you require and we'll quote on flame-cutting, shearing, pressing, blanking, bending or other shaping of the steel.

We have more than 150 major machines for prompt attention to your needs. By-Products has thousands of dies ready for use—can often save you the cost of new dies. And we can reduce your scrap losses—you pay no freight, no handling charges on scrap. Scrap allowance is made right at the mill where its value is highest.

Steel Plate Shapes are made from carbon, alloy and clad steels. Plate sizes range up to 195″ wide, or up to 25″ thick. Send for Bulletin No. 270. By-Products Steel Co., Division of Lukens Steel Company, 419 Strode Avenue, Coatesville, Pennsylvania.

LUKENS
BY-PRODUCTS STEEL DIVISION

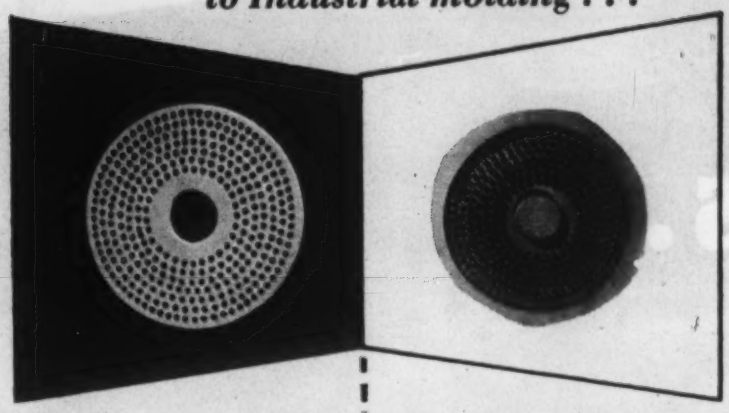
BY-PRODUCTS STEEL CO.

STEEL PLATE SHAPES

FLAME-CUT ★ SHEARED ★ PRESSED ★ BENT ★ BLANKED ★ WELDED

A flexible answer

to Industrial molding . . .



This is a Plastitool brush head all ready to have bristles inserted in the expertly cast cavities. Plastitool here replaces plywood to prevent warping and to insure longer life for the tool.

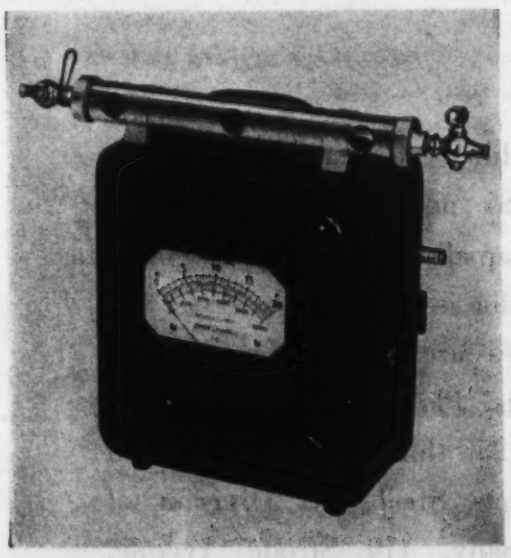
This type of casting is made possible with PLASTIFLEX—the accurate flexible molding material. Plastiflex can be stretched like rubber; makes intricate molds in one piece; and can be melted for re-use.

One or both of these materials may answer your casting problem. For further information, write:

CALRESIN CORPORATION
CULVER CITY, CALIFORNIA

PLASTITOOL • PLASTIFLEX • PLASTIFORM • PLASTIGLAZE

Check CO_2 Efficiently!



Engelhard portable CO_2 Gas Analyser permits quick determination of heat treating furnace conditions efficiently, without taking samples of combustion gases back to the laboratory. This means that furnace atmosphere conditions are known instantly and any necessary furnace adjustments can be made on the job with visual measurement on a direct reading meter.

This FLUALYZER, as we like to call it, is an instrument incorporating sensitivity, ruggedness and complete portability. The ENGELHARD thermal conductivity method of gas analysis assures highest accuracy. To complete the setup, temperature readings of flue gases can also be taken with the same instrument, if you desire.

Write for prices and Bulletin 700

CHARLES ENGELHARD, INCORPORATED
900 Passaic Ave. • East Newark, N. J.

News of...

ENGINEERS COMPANIES SOCIETIES

Steel Corp. to supervise and advise on activities of the company's 16 subsidiaries. He has aided in steel plant construction in several foreign countries. He will now concentrate on improving the Central Iron & Steel Co. He belongs to several technical societies.

Louis D. Alpert has been named assistant to the Pacific Coast general manager, Federated Metals Div., having joined the company in 1935, in the research department at Perth Amboy, N. J. He then did research at the Whiting, Ind. plant, was placed in charge of brass operations, and became superintendent of the San Francisco plant. *John S. Selfridge, Jr.* has become superintendent of the San Francisco plant, having at first been assistant metallurgist there and then assistant superintendent of the plant. *Robert C. Caldwell* succeeds Mr. Selfridge, Jr., having been in charge of the Brass Ingot Dept.

Dr. *Wallace Reed Brode,* who has done outstanding work in spectroscopy, has been made associate director, National Bureau of Standards, succeeding Dr. *Hugh L. Dryden,* who has entered aeronautical research. He has been professor of chemistry at Ohio State University. He was a recipient of the Guggenheim Memorial Foundation fellowship, studying in Europe. During the war he was with the Office of Scientific Research & Development. He has authored several technical articles and belongs to several societies, including the American Society for Testing Materials.

M. W. Reed has become chief engineer, U. S. Steel Corp. of Delaware, having served with subsidiaries of the corporation continuously since 1916. He started in the steel industry as a wire rope tester. He became chief engineer, Carnegie-Illinois, in 1939.

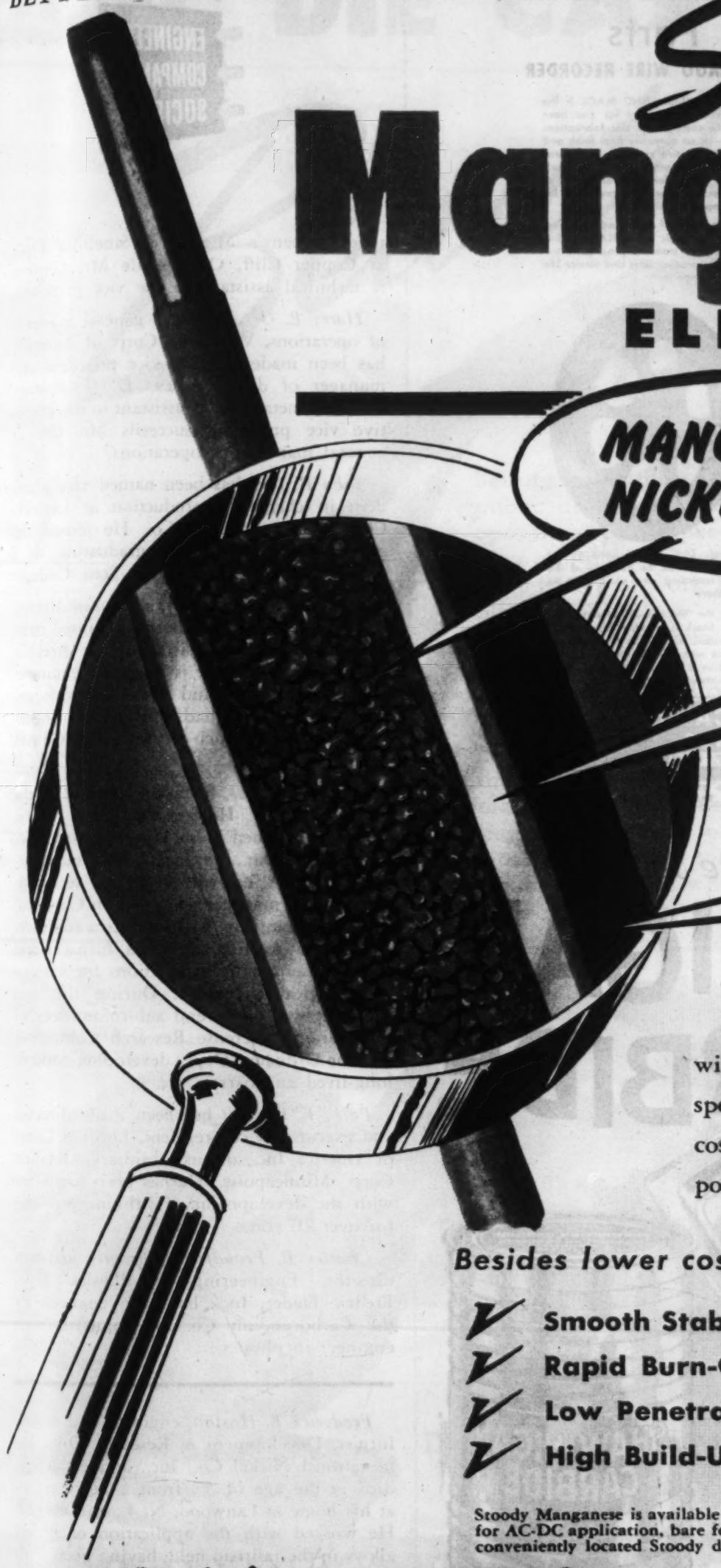
E. A. Cappelen Smith, of Guggenheim Brothers, has been awarded an honorary degree of Doctor of Engineering by Drexel Institute of Technology. The citation was written and delivered by *A. W. Grosvenor,* professor of metallurgical engineering at Drexel.

A. B. Muskett has been appointed manager of manufacturing, General Electric X-Ray Corp., Milwaukee. He was formerly with the Ford Motor Co. and more recently with General Motors Corp., Detroit. Prior to his new connection he was a manufacturing consultant in G. E.'s executive department.

T. H. Wickenden, manager, Development & Research Div., International Nickel Co., Inc., has been elected a vice president. He is well known in engineering circles in the automotive industry, as engineer and metallurgist. Among new vice presidents of the International Nickel Co. of Canada, Ltd. are *Ralph D. Parker* and *J. Roy Gordon.* Mr. Parker is general superintendent of

BETTER WELDABILITY • HIGH BUILD-UPS RAPID DEPOSITION RATE

Stoody Manganese ELECTRODES



MANGANESE—NICKEL ALLOY

MILD STEEL TUBE

SPECIAL COATING for smooth, stable arc

STOODY MANGANESE is a fabricated electrode having a mild steel tube filled with ferro-manganese and nickel particles. This special manufacturing process reduces electrode cost, provides better weldability and assures deposits having full Hadfield properties.

Besides lower cost you get these desirable features:

- ✓ Smooth Stable Arc
- ✓ Rapid Burn-Off Rate
- ✓ Low Penetration
- ✓ High Build-Up
- ✓ Low Spatter Loss
- ✓ Easy Slag Removal
- ✓ AC-DC Application

Stoody Manganese is available in 1/4", 3/16" and 5/32" rod diameters; coated for AC-DC application, bare for DC only. Try 50 lbs. today! Sold by over 600 conveniently located Stoody distributors.

STOODY HARD-FACING ALLOYS
Retard Wear Save Repair

STOODY COMPANY
1159 WEST SLAUSON AVE., WHITTIER, CALIFORNIA

The New BLACK MAGIC Zinc Black Protects Important Parts

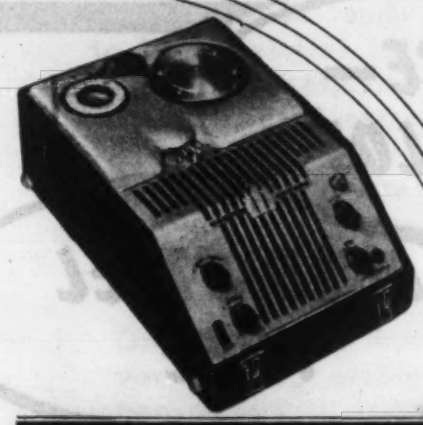
ON THE WEBSTER-CHICAGO WIRE RECORDER

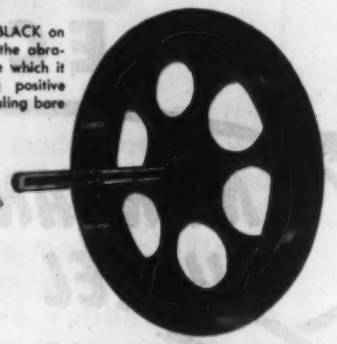
Black-Magic ZINC BLACK is used on the spool of the Webster-Chicago Wire Recorder shown below because it does not build up the diameter and is a good bond for the silk screen painted trade name.

Black-Magic ZINC BLACK is the modern treatment for zinc base die castings and zinc fabrications —as an attractive final finish and an effective corrosion and abrasion resistant. It is also an excellent bond for paint, and when so used, it affords full protection for unpainted areas.

Because of these advantages, Black-Magic ZINC BLACK is becoming "standard practice" wherever product sales and service life are important.

Black-Magic ZINC BLACK on the mandrel resists the abrasion of a felt brake which it engages, affording positive action without revealing bare metal.





Black-Magic ZINC BLACK, used on the take-up reel, resists the abrasion of the magnetic recording wire which rides on the periphery.

Write for the "Black Book" of details on our zinc black and other Black-Magic metal finishes. Also, for a first-hand acquaintance with this zinc black, suggest you send us a product for sample processing without obligation.

MITCHELL-BRADFORD CHEMICAL COMPANY

MODERN METAL FINISHES

• 2446A MAIN ST., (Stratford) BRIDGEPORT, CONN. •

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BLACK-MAGIC OXIDE BLACKING SALTS
WITCH-DIP & WITCH-OIL FINAL FINISHES

SILCO Glass-Base PROTECTIVE COATING
HEAT TREATING SALTS. CLEANERS. ETC.

Master Hands on Intricate Jobs use

SHAWINIGAN CARBIDE

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EMPIRE STATE BUILDING,
NEW YORK 1, N.Y.

News of...

ENGINEERS COMPANIES SOCIETIES

that company's Mining & Smelting Div., at Copper Cliff, Ont., while Mr. Gordon is technical assistant to the vice president.

Harry E. Orr, formerly general manager of operations, Vanadium Corp. of America, has been made assistant vice president and manager of district sales. *D. G. Bowser,* formerly metallurgical assistant to the executive vice president, succeeds Mr. Orr as general manager of operations.

John B. Ives has been named vice president in charge of production at Laclede-Christy Clay Products Co. He joined the company in 1926 upon graduating as a ceramics engineer from Iowa State College.

Julian W. Feiss, editor, *American Mining Congress Journal,* has been appointed mineral consultant and assistant to the director, Bureau of Mines. He is a mining engineer, mineral economist and writer of wide experience. He has had considerable industrial experience, such as with the Climax Molybdenum Co.

George N. Vitt, formerly assistant to the president, A. F. Holden Co., New Haven, Conn., has joined John Ek Industries, Inc., Guilford, Conn., engineers and manufacturers, where he will serve as secretary, director and manager. The Crown Chemical Div., that company, will produce a complete line of heat-treating salt baths, furnaces and complete automatic installations for various metallurgical processes. During the war Mr. Vitt was on several sub-committees of the National Defense Research Committee and the Ordnance Dept., developing rockets, long-lived gun barrels, etc.

Percy E. Landolt has been made director and executive vice president, Lithium Corp. of America, Inc., and its subsidiary, Metalloy Corp., Minneapolis. He has been identified with the development of lithium products for over 20 years.

Charles B. Proudfoot, formerly assistant director, Engineering & Physics Div., Fredric Flader, Inc., has been engaged by the Carborundum Co. as senior research engineer in physics.

Frederick P. Huston, engineer and metallurgist, Development & Research Div., International Nickel Co., Inc., at New York, died at the age of 57 from a heart attack at his home at Fanwood, N. J., on Dec. 29. He worked with the application of nickel alloys in the railroad field, having been with the company over 20 years. He helped develop nickel-clad steel plate and was co-inventor of a process for producing Inconel-clad, or stainless-clad plate. He belonged to an unusually large number of technical societies. Among his survivors are a son, Frederick P. Huston, metallurgist, Hunting-

ZINC DIE CASTINGS for *Beautility*

Beauty and utility combined! The critical buying public demands quality of product, simplicity of operation, easy upkeep and outstanding appearance when they choose something with which they have to live or work. Beautility—appearance combined with utility — is therefore stressed increasingly by all manufacturers. And when these are the objectives, zinc alloy die castings invariably solve many design and manufacturing problems.

Industry's preference for zinc as a base for die castings is indicated by the fact that normally three times as much zinc is used for this purpose as all other metals combined. This is due to ease of casting and finishing, excellent physical properties, close dimensional tolerances and wide variety of beautiful finishes which can be attained with zinc base die castings.

New Haven "HALO" Alarm Clock

DIE CASTING is the Process • ZINC, the Metal
***BUNKER HILL*, the Preferred Zinc**

BUNKER HILL 99.99+% ZINC

EASTERN SALES AGENTS **ST. JOSEPH LEAD COMPANY** 250 PARK AVENUE, NEW YORK
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Precision Investment Casting is a Science
ELIMINATE GUESSWORK WITH
THERMOTROL
THE CASTING MACHINE WITH A MEMORY!
Successful casting demands accurate control! Precision casting by the lost wax process with THERMOTROL gives you this... and MORE. Even a novice can be trained in less than one hour... to make perfect casts!
Our latest publication, "Precision Casting by THERMOTROL," not only gives you complete details on this amazing casting machine, but is also chock-full of other interesting information on Precision Investment Casting!
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News of...

ENGINEERS COMPANIES SOCIETIES

ton Works research laboratory, International Nickel.

Companies

The *Nichols Wire & Steel Co.*, Davenport, Iowa, has changed its name to *Nichols Wire & Aluminum Co.* Its president, Frank R. Nichols, explains that for 38 years steel has been the company's principal business. Now they are convinced that aluminum is not merely a substitute, but "stands on its own feet competitively with steel." He points out there isn't any grey market in aluminum and says that the company's business has grown substantially since they have gone into aluminum.

The *Lustron Corp.*, Columbus, which will produce low-cost, quality homes of porcelain enamel steel at the rate of 30,000 yearly, has ordered $4,000,000 worth of machinery, including presses as large as 600 tons. The houses will be turned out on an automobile assembly line basis.

The *National Industrial Chamber*, 82 Beaver St., New York, has developed a procedure for placing manufacturers in touch with sub-contractors with available machinery within 48 hr. Suppose a ball point pen manufacturer gets a sudden large order from a department store. National Industrial Chamber will point out a screw machine shop that can handle the rush job.

The *Lincoln Electric Co.*, Cleveland, passed out year-end bonuses of $3,800,000 to 1155 workers, the checks ranging from $25 for short time employees to $35,000 for top managerial and engineering talent. Tops for yearly earnings in key shops were: Machine shop, $9457; welding, $8982; hand assembly, $9705; punch press, $9180. James F. Lincoln stated that their bonus is not a Christmas present—every cent is earned.

The *Westinghouse Electric Corp.* and the *Aluminum Co. of America* have joined with the *University of Chicago* in a combined program of atomic research. The companies will have access to the university's laboratories and scientific knowledge.

The *Reynolds Metals Co.* has acquired the Gary, Ind. plant of the Reynolds Research Corp., which will be operated as the Plastics Div. of the Reynolds Metals Co. Manufactured here is a new film made from Geon latex, called "Reynolon," which may be sewed or electronically heat-sealed and is adapted for use on automatic packaging equipment.

American Brake Shoe Co.'s two new nonferrous foundries at Niles, Ohio, and Meadville, Pa., were opened in December. The first will make railroad journal bearings, while the Meadville foundry will turn out bronze bearings and castings and will spe-

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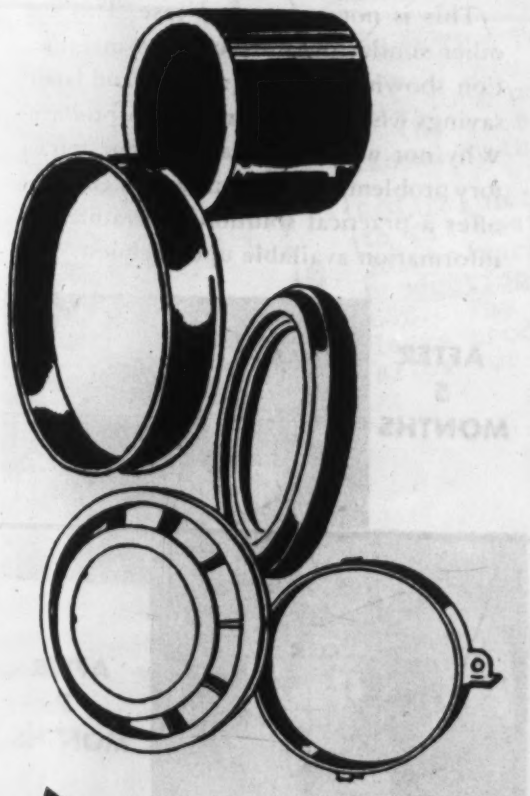

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ENGINEERS COMPANIES SOCIETIES

cialize in copper, brass and bronze for railroads and steel mills; also, precision machine bearings for Diesel engines and other high-speed, high duty service.

Koppers Co., Inc. and *Compania de Acero del Pacifico of Chile* have made a contract whereby Koppers will supervise construction, engineering and management of the first integrated steel plant to be built in Chile. The $50,000,000 plant will be built at Concepcion and will be completed in 1949. It will produce 250,000 tons of finished steel yearly.

The *American Bronze Div., Metals Disintegrating Co.,* Elizabeth, N. J., has sold its buildings and 26 acres of land at Verona, N. J., to the *Kuzmick Development Corp.,* which will use much of the property for a research laboratory in the field of grinding wheels, abrasives and allied products.

Three automatic temperature control companies have merged: the *Robertshaw Thermostat Co.,* Youngwood, Pa., the *Fulton Sylphon Co.,* Knoxville, Tenn., and the *Bridgeport Thermostat Co.,* Bridgeport, Conn., have joined as the *Robertshaw-Fulton Controls Co.*

Kennametal Inc., Latrobe, Pa., has opened its own Eastern district office at 6 W. Broadway, New York.

The *Air Reduction Sales Co.* has formed a new wholly-owned subsidiary, the *Air Reduction Pacific Co.,* with headquarters at Room 1813, Mills Tower, 220 Bush St., San Francisco 4.

Increased facilities for the manufacture of rolling mill equipment in the strip steel and other rolled fields have been completed at the Vandergrift, Pa., plant of *United Engineering & Foundry Co.,* Pittsburgh.

Lester B. Knight & Associates, Inc., Chicago, consulting engineers specializing in foundries, have opened a New York office at 30 Church St., New York, in charge of F. E. Bradway.

The *Westinghouse Electric Corp.* has issued a 24-page booklet giving complete descriptions of sound motion pictures and slide films available for industrial and civic use. Among the subjects covered are: electronics, electricity, radio, RF heating, research, industrial maintenance and resistance welding control. Copies may be obtained by addressing Westinghouse: Film Section, P. O. Box 868, Pittsburgh 30.

A new plant to house the *Specialties Div., Yale & Towne Mfg. Co.,* at Salem, Va., will be in operation in the spring.

Spray painting classes for industrial finishers for the first half of 1948 are announced by the *De Vilbiss School of Spray Painting,* Toledo, Ohio. One-week courses begin Feb. 2, March 1, May 10 and June 7.

$27.00 INVESTMENT SAVES $714 IN SEVEN MONTHS AT FORGE

Case History No. 107*

*THOUGHT YOU might be interested," writes a blacksmith foreman, "in the results from our use of Brickseal, on hoods for our heavy forges. Heretofore, it was necessary to completely replace the entire hoods every twenty-four days (average). Since using Brickseal Refractory Coating on these hoods, they have been in continuous operation for over seven months and shells are still in excellent condition. We figure a complete hood costs $43.00 to build and by the use of Brickseal on three hoods, we saved $714.00 in a period of seven months."

This is not an unusual case. This and other similar ones are open to investigation showing amazing money- and labor-savings where refractories are a problem. Why not write today about your refractory problems and let our factory engineer offer a practical solution. Literature and information available upon request.

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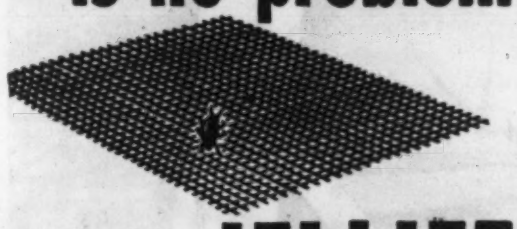

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News of...

ENGINEERS COMPANIES SOCIETIES

The *Portsmouth Steel Corp.* has bought a noncontinuous sheet mill, with annual capacity of 100,000 tons. The plant is being dismantled at Saulte Ste. Marie, Ont., for transfer to Portsmouth, Ohio.

The *Linde Air Products Co.* is starting construction of an oxygen filling station and acetylene producing plant at Little Rock, Ark.

The *Permanente Metals Corp.* is considering the addition of aluminum rod, bar and wire making facilities at its Spokane, Wash. rolling mills.

Societies

The *Industrial Furnace Manufacturers' Assn.*, 420 Lexington Ave., New York 17, has chosen five judges to function in the $1500 prize contest for the best published article on industrial furnace, kiln or oven applications. The contest embraces articles published from Oct. 1, 1947 to Sept. 30, 1948, inclusive. Articles relating to the specific advantages obtained by the use of modern industrial furnaces for heat treating, processing or melting are eligible. Technical society articles subsequently published in a trade paper also will be considered. The judges are: Alexander H. d'Arcambal, vice-president and consulting metallurgist, Pratt & Whitney Div., Niles-Bement-Pond Co.; Dr. E. S. Davenport, asst. to vice president, United States Steel Corp.; George W. Mason, president, Nash-Kelvinator Corp.; R. H. McCarroll, director of chemical engineering and chemical and metallurgical research and chairman of the industrial engineering commission, Ford Motor Co.; and Dr. S. R. Scholes, dean, New York State School of Ceramics, Alfred University, Alfred, N. Y.

The *American Society of Mechanical Engineers* has presented a scroll to Charles Edward Lucke, professor emeritus of mechanical engineering at Columbia University to honor his idea of organizing the society into units or professional divisions of the parent group. His plan of "societies within a society" forms the framework of the A.S.M.E., which today comprises 24,000 members in 19 professional divisions.

The *Gray Iron Founders' Society* recently formed a management executives' group at St. Louis and another at Rochester, N. Y. In fact, it is the purpose to found 40 such groups throughout the country. George D. Branston, formerly of Campbell, Wyant & Cannon Foundry Co., Muskegon, Mich., is representing the foundry industry on a special mission of the U. S. Department of Commerce to survey military scrap in Germany. The trip will occupy January and February.

D. E. Van Deusen, president and general

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GRADE "C" *(Primos)*	Vanadium . . . 35-45% Silicon . . . max. 1.25% Carbon . . max. 0.20%
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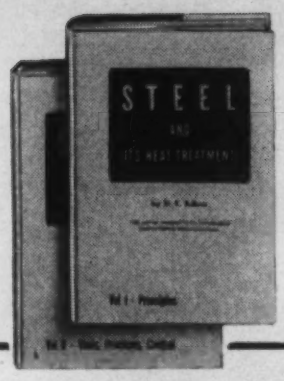

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News of...

ENGINEERS COMPANIES SOCIETIES

manager, Kelly Reamer Co., Cleveland, has been elected president, *Cutting Tool Manufacturer's Assn.*, succeeding Emil Gairing, president, Gairing Tool Co., Detroit.

At the first international conference of the *Electron Microscope Society of America* at Philadelphia in December, the subject of the symposium was a proposal for a comprehensive training program to relieve the present shortage of electron microscopists. Papers were read by experts from England, Holland, Australia and Canada.

The *Society for the Advancement of Management* will hold its national spring conference on management planning and controls March 4 and 5 at the Sheraton Hotel, Chicago. The theme of the forum is "Continuously Successful Management." Many nationally-known speakers will participate in this forum.

The *American Standards Assn.* has named as administrative head Vice-Admiral George F. Hussey, Jr. USN (Ret.), wartime chief of the Navy's Bureau of Ordnance. Cyril Ainsworth, who has been in charge of the technical activities of the ASA, will serve with Vice-Admiral Hussey as director of operations. The organization during 1948 expects to increase its activities to three times that of pre-war.

The Steel Div. research committee of the *American Foundrymen's Assn.* will sponsor a study of the influence of mold conditions on the development of hot tears in steel castings. Clyde Wyman, metallurgist, Burnside Steel Foundry Co., Chicago, heads the research group. The AFA has established the "Eastern New York Chapter," headquarters Albany, serving also Vermont and Western Massachusetts. This is the AFA's 39th chapter and the fifth in New York State. Charles E. Kilmer, Jr., Swan-Finch Oil Corp., is chapter chairman.

Ohio State University has established a department of welding engineering which, it claims, is the first of its kind in the nation. For nine years the university has taught welding as a division of the Department of Industrial Engineering.

The *American Hot Dip Galvanizers' Assn., Inc.*, 1611 First National Bank Bldg., Pittsburgh 22, announce a 16-mm. motion picture sound film depicting zinc coating by the hot dip galvanizing process industry. It is primarily educational, with an entertaining theme. Entitled "Must It Rust," its showing time is 25 min.

The *Division of General Education, New York University,* will offer a course in Theory and Application of Welding for the first time during the spring term. It will be essentially theoretical in nature, correlating elementary metallurgy and design and their application in electric welding.

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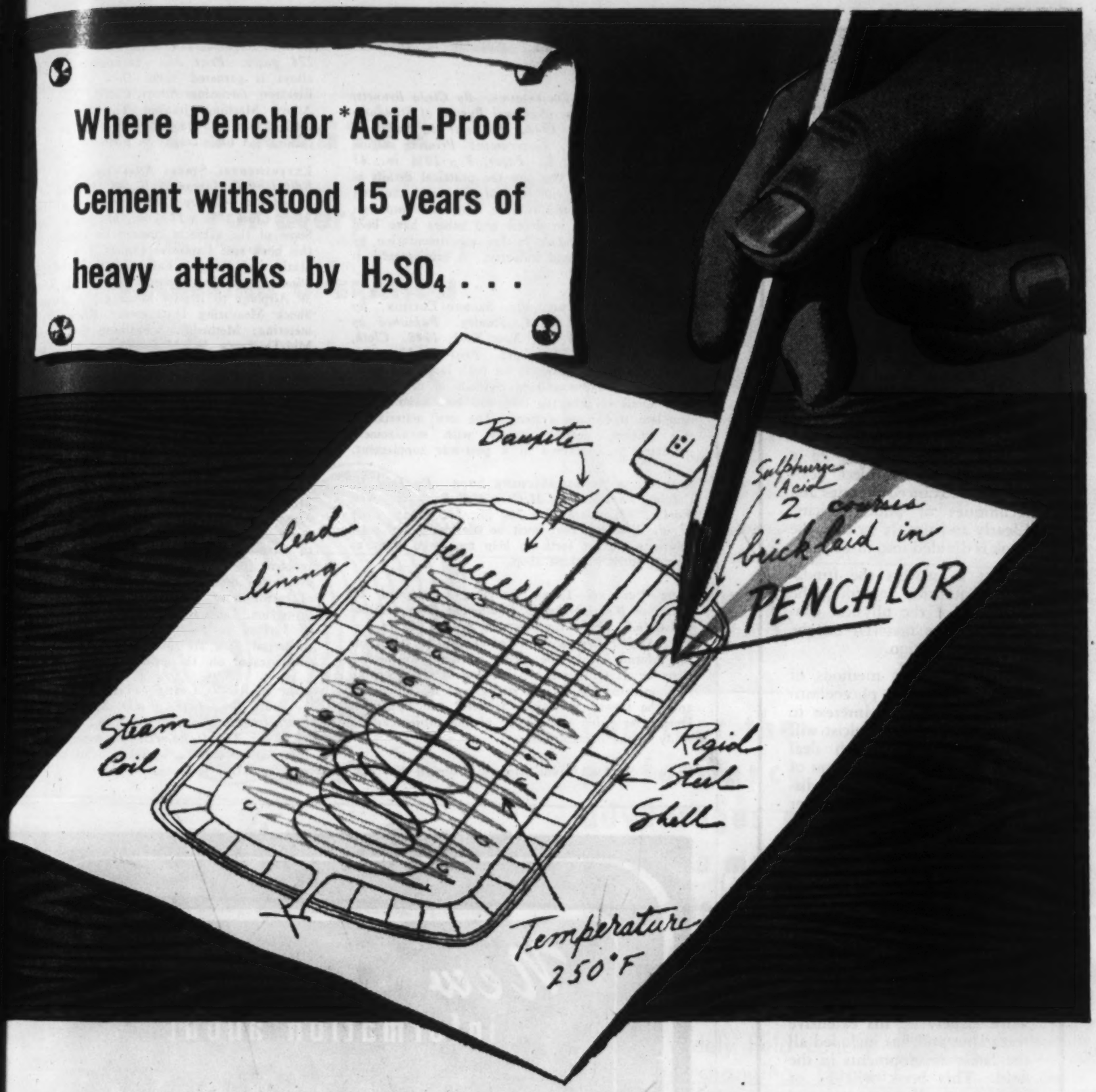

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Part I answers the fundamental question regarding the influence of the physical constants of the material on the stress distribution.

Part II covers methods of two-dimensional photoelasticity. Of particular interest to the engineer and physicist will be the chapters which deal with the numerical solution of Laplace's equation. This discussion enters into many other branches of engineering and physics, such as heat transfer and electricity.

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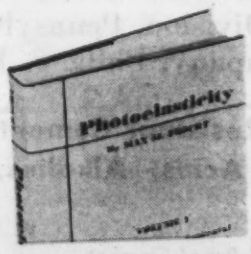
The author has based this work largely on his extensive researches and has included all the latest developments in the field. This book will be of interest to all engineers and students of the theory of elasticity as well as to technicians dealing with photoelastic problems.

March 1948
491 Pages
Illus.
Prob. $10.00

Vol. I—1941
411 Pages
$6.50



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Other New Books

PRINTED CIRCUIT TECHNIQUES. *By Cledo Brunetti & Roger W. Curtis. National Bureau of Standards Circular No. 468, 1947. For sale by Supt. of Documents, U. S. Government Printing Office, Washington 25, D. C. Paper, 8 x 10¼ in., 43 pages. Price 25c.* Outlines the practical details of the use of printed circuits and represents the first general treatise on this subject. The main processes have been treated in detail and others have been mentioned to stimulate further experimentation by other laboratories and industry. A bibliography is included.

RUNNING A MACHINE SHOP—SECOND EDITION. *By F. H. Colvin & F. A. Stanley. Published by McGraw-Hill Book Co., New York, 1948. Cloth, 5½ x 8½ in., 521 pages. Price $4.25.* This practical guide to practices for both large and small shops covers subjects from methods of determining what kinds of jobs the shop can best handle to a complete tool room system. The new material in this edition, dealing largely with management problems, is contained in a post-war supplement.

STARTING A SMALL MACHINE SHOP. *By Fred H. Colvin. Published by McGraw-Hill Book Co., New York, 1948. Cloth, 5 x 7⅝ in., 212 pages. Price $2.50.* Problems that must be considered and some solutions are set forth to help men who want to start a small machine shop.

SHOT PEENING—THIRD EDITION. *Published by American Wheelabrator & Equipment Corp., Mishawaka, Ind., 1947. Cardboard, 6 x 9 in., 181 pages. Price $1.50; free to interested executives.* Contains the information in the earlier editions plus discussions by J. O. Almen on the use of shot peening for improving the fatigue strength of machine parts and the theory of fatigue failures, and by O. J. Horger reviewing the history of the subject and a study of the literature.

ELEKTRON MAGNESIUM ALLOYS—FOURTH EDITION. *Published by F. A. Hughes & Co., Ltd., Lond N.W.1, England, 1947. Cardboard, 6½ x 9¾ 224 pages. Price 25s.* Information on Elekt alloys is garnered under these chapter headi Elektron, Zirconium Alloys, Casting Alloys, Wrou Alloys, Maching, Joining, The Working of Sh Design, Surface Treatment, Fire Risks and Ap cations. A bibliography is included.

EXPERIMENTAL STRESS ANALYSIS, VOL. V, NO. *Edited by C. Lipson & W. M. Murray. Publis by Addison-Wesley Press, Inc., Cambridge Mass. Cloth, 8½ x 11¼ in., 136 pages. Price $6.* Some of the subjects covered by the 14 papers this book are: Explosive Impact Tests; Criterion Static and Fatigue Failures; Experimental De mination of the Dynamic Structural Response an Airplane to Impact Loadings; A Proposed N Shock Measuring Instrument; Radio Pulse Te metering; Method of Obtaining the Stress at Mid-Thickness by Measurements from Only O Surface of a Plate; Bonded Wire Strain Gage Te niques for Polymethyl Methacrylate Plastics; Eff of Temperature Gradients upon the Introduction Residual Stresses in Weldments or Other Structure and Recent Contributions to the X-Ray Method the Field of Stress Analysis.

METALLIC CORROSION (EL PROBLEMA DE LA CO ROSION METALICA). *By E. Jimeno. Published Ministry of Marine, Spanish Institute of Oce ography, Madrid, Spain, 1947. 6½ x 10½ in., 2 pages.* After a resume of the economic losses d to corrosion and of the organizations tackling t problem in various countries, a concise but co prehensive description is given of the mechanis of corrosion of various types, and of methods protection. Up-to-date information given by auth of various nationalities is well summarized. F numerical data are given, attention being prope concentrated on the principles involved.

HOW TO RUN A LATHE—45TH EDITION. *Publish by South Bend Lathe Works, South Bend 22, I Leatherette or paper, 5⅜ x 8 in., 128 pages. Pr $1.00 or 25c (leatherette or paper, respectively* Information on the operation and care of met working lathes is given.

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Use Kester ACID-CORE solder for general work; KESTER ROSIN-CORE solder for all electrical work.

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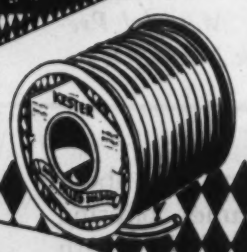

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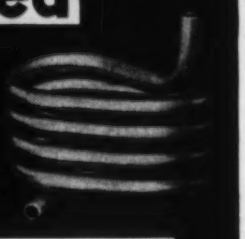
Eastern Plant: Newark, New Jersey Canadian Plant: Brantford, Canada

This Is *Ductility* In Stainless Steel Fabricated From *Trentweld* TUBES

Flared

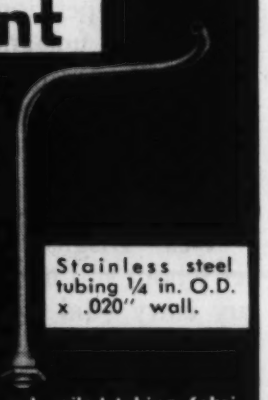
Stainless steel tubing 1-1/8 in. O.D. x .065" wall flared to 2-1/16 in. dia.

Coiled



Stainless steel tubing ½ in. O.D. x .028" wall. Bending radius is 1-¼ in.

Bent



Stainless steel tubing ¼ in. O.D. x .020" wall.

Bent and coiled tubing fabricated by Trent Engineering Co. East Troy, Wisconsin

Consider the performance advantages of this versatile material as applied to your product or operation

Old, widely held conceptions are changing. Ductile stainless steel tubing produced by Trentweld methods can be adapted to new fields where the desirable characteristics of stainless can improve your product's appearance, service, and efficiency.

It's no accident that Trentweld tubing provides this extraordinary capacity plus the ability to withstand repeated heating and cooling, high pressures, vibration, etc. . . . for it is made to standards beyond the commonplace, by an advanced and exclusive method of rolling and fusion welding. A copy of the Trentweld bulletin should be of value to you. It is yours for the asking, as is Trent engineering service based on advanced metallurgical research and practical field experience in scores of industries. Please address Dept. 21.

TRENTWELD STAINLESS STEEL TUBES

General Office and Mill: East Troy, Wisconsin

TRENT TUBE MFG. CO.

District Offices: New York, Chicago

The Last WORD

by T. C. DU MOND

Dear "Disgusted":

No, this hasn't become an advice-to-the-lovelorn column, but we did receive a letter the other day signed "Disgusted." Since there was no other signature, this is the only way we can reply to "Disgusted." He challenged us to publish his letter, which was full of venom about M & M and one of the winners in the 1947 Achievement Award competition, knowing as he must that an unsigned letter as defamatory to another manufacturer as his is, would never be published by any fair, right-thinking editor. Anyway, dear other readers, you are invited to peek over our shoulder while we answer.

"Dear 'Disgusted': The Award winner whom you malign made the necessary entry (did *you?*) in the competition and backed it up with case-history evidence of economic advantages of his development. This impressed our judges—an independent group of seven intelligent men—sufficiently for them to grant the Award you question. Unless *you* can *disprove* the claims made by the winner of the Award to which you take exception, this is all the publicity we'll be able to give your letter. Of course, if you are ready to assume the costs of a libel suit, we'll be glad to run your letter *over your signature.* (Signed) The Editors —P.S. Don't talk to us about 'guts.' At least *we're* not afraid to identify ourselves!"

St. Patrick's Oats

I'm often amazed at the tasks which fall to the research departments of large companies. A recent issue of the *Alcoa News-Letter* reports one such odd job. It seems that a housewife bought a shiny new set of aluminum cooking utensils. Everything was bright until said lady cooked some oats for hubby's breakfast. To her amazement and her husband's dismay, the oats wound up a brilliant green. Try as she might every batch of oats developed a beautiful grass-like color. She tossed her problem in the ample and collective lap of Alcoa. After many false starts, researchers found the answer. Our lady was using iodized salt and apparently failed to stir thoroughly the oats, salt and water. When the iodized salt is not thoroughly mixed in, it sets up a reaction with the oats and they turn color. You, too, can have Irish oats any time you like—regardless of the pots used—by simply pouring in the iodized salt without stirring.

News About Stainless

Readers of the *New York Sunday Times* of a few weeks ago were probably startled to see in that usually accurate journal that now stainless steel was available in forms other than castings. What led to this little gem of misinformation was the announcement of The Carpenter Steel Co. that a special grade of stainless once only produced in cast form could now be had in bar stock, wire, strip, tubing and pipe. If you want to get the latest information on this new stainless development, see the *New Material Preview* in this issue of M & M.

Boomerang

Recently we have heard tales about some motor car companies offering dealers an extra automobile in return for each ton of scrap iron and steel they supply. Although this has worked fine in cases where "junkers" were scrapped, it has to be halted in others where it was found that car dealers were helping to bid up the price of scrap and just confusing the whole situation. I'm willing to turn in the ton and one-half of scrap I've been driving if some automobile manufacturer offers me a deal like that. Who's first?

More on Beer in Cans

I have been reminded *re* my lament about the possible dearth of cans for beer that there is a silver lining to this cloud. Lee Ferguson of Sanger-Funnell advertising agency points out that the one-way glass bottles now being used by some brewers still make unnecessary the toting of empties.

Woes Upon Woes

As if steel companies were not having enough trouble today being squarely in the middle of a triangle formed by government, consumers and labor, stock market manipulators are trying to make a rectangle out of the situation. Fortunately for the present owners of the steel company involved, authorities broke up the plot which could easily have wrecked a legitimate company. Too, from the records of some of those involved in the shady scheme, it could be that someone had plans to acquire a source of supply to feed the "gray market."

One More Use for Scrap

Recent reports from Germany tell us that some scrap metals are to be used in making simple shoes for unshod Germans. Let's hope they use magnesium or aluminum scrap rather than copper, lead or steel, for obvious reasons. Chief reason for this bit of resourcefulness is the high price of leather shoes on the black market ($50 a pair). If shoe prices continue upward in this country, I'm going to put in my order for a few pairs of chromate-treated aluminum shoes—maybe black, tan and, for flashy occasions, possibly a conservative blue.

Comes the Dawn

Some months ago Editor-in-Chief Peters concocted an editorial which sang the blues about "Plastics Have Names That Are Long." The theme was to the effect that such names as "methacrylates," "polydichlorostyrene," and "vinylidene copolymer" could lead to nothing but bewilderment and confusion. Mind you, we're not trying to take all the credit, but apparently our clarion call has been heard. From Dow Chemical Co. comes the word that its trademark rights to Saran (now to be spelled with a small "s") are to be released so that the name can be used generically to identify the series of thermoplastic resins chemically known as vinylidene chloride copolymers. Anyone else care to help the cause along?